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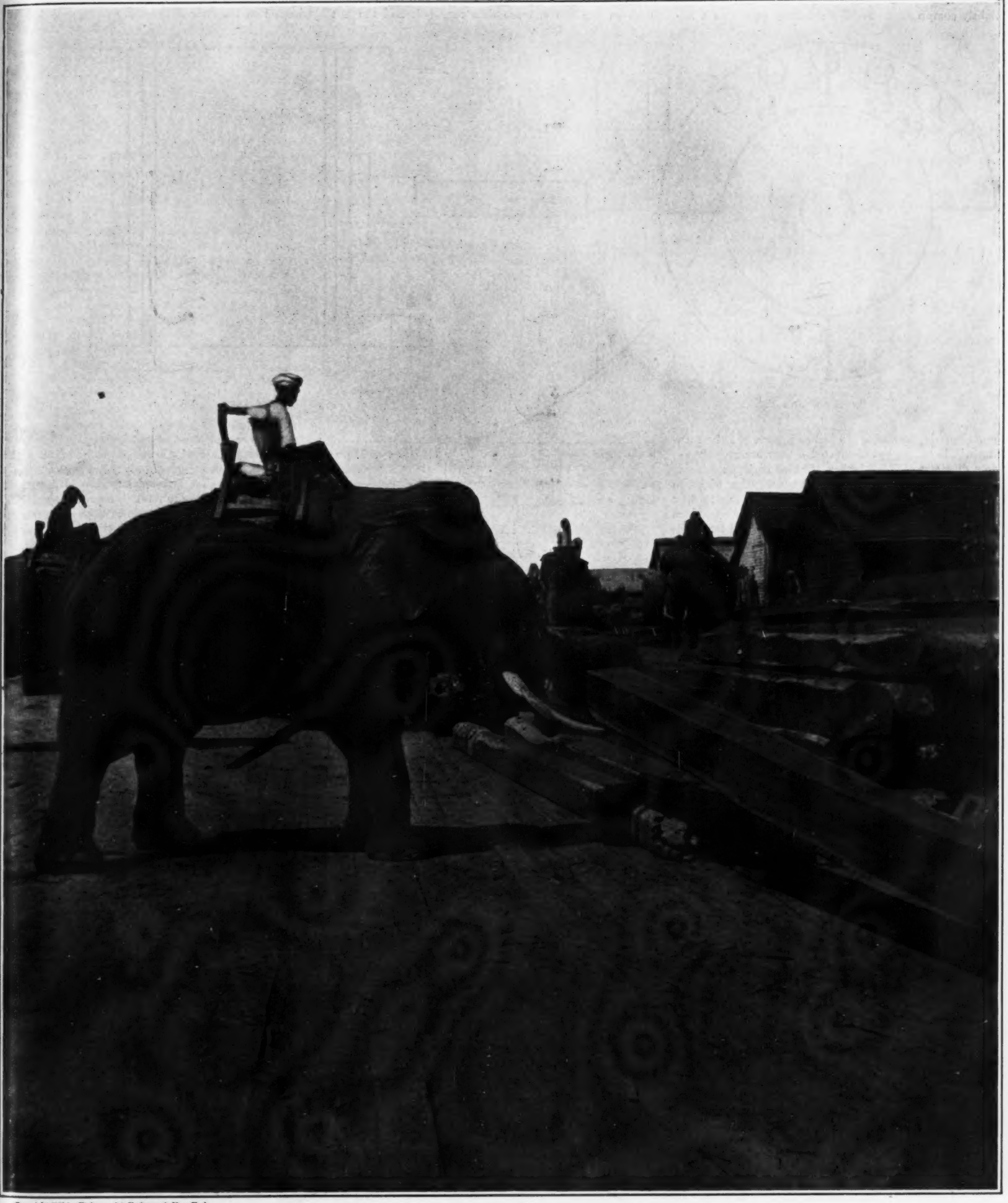


The Elephant is the Mandalay Counterpart of the Battery-truck Crane.

LOCATING THE FRICTION IN OUR TRANSPORTATION SYSTEMS.—[See page 244.]

A Self-Starting Single Phase Induction Motor—II*

Directions for Its Construction

By Charles F. Fraasa, Jr.

Concluded from SCIENTIFIC AMERICAN SUPPLEMENT No. 1945, Page 227, April 12, 1913

CONSTRUCTION OF ROTOR, STATOR WINDING, ETC.

The rotor is constructed of No. 29 sheet steel, enough sheets being used to make a stack 1¾ inches thick when tightly compressed. These sheets may be cut on a tinner's squaring shears, 3 5/8 inches square, but the turning will be somewhat facilitated if they are roughly cut to a diameter of 3 5/8 inches. Shellac or japan one side of each disk, clamp the stack of sheets together with two pieces of 1/8-inch copper on top and bottom, and drill a ½-inch hole through the center. Then center a 6¾-inch piece of ½-inch steel rod and thread one end for a distance of 3 1/8 inches, and the other end for a distance of 2 1/8 inches. These ends are threaded for standard ½-inch hexagon nuts, two of which should be provided. The rotor disks are then put on the steel rod with a 1/8-inch copper disk on the bottom and three of the 1/8-inch copper disks on the top and the hexagon nuts turned on, clamping the disks tightly together. Mount the whole in the lathe again and inscribe a 3-inch circle on one of the copper disks with the tool. Remove from the lathe and divide the circumference of this circle into 17 equal parts, center-punching each to locate the slot for the bar.

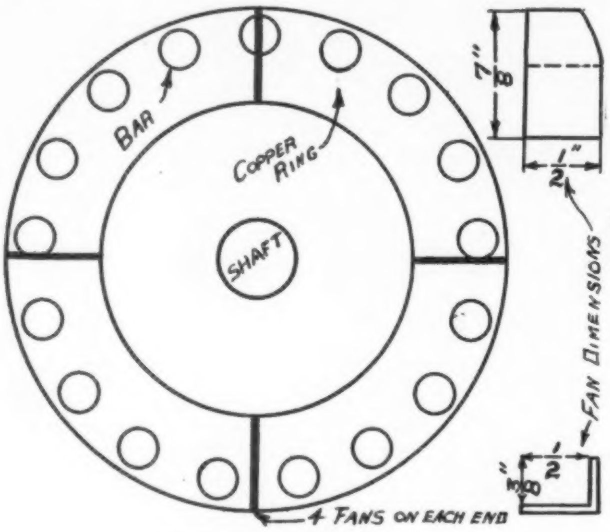


Fig. 9.—Rotor and Fans.

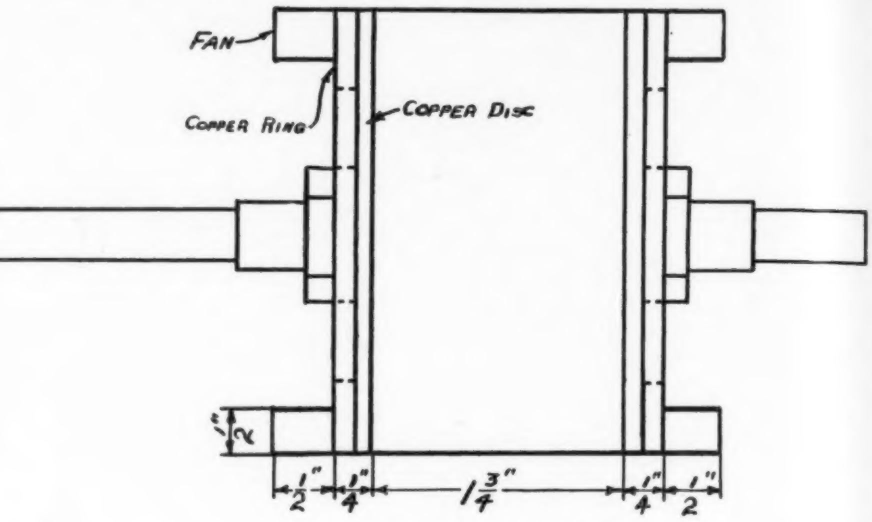


Fig. 10.—The Assembled Rotor.

Seventeen 9/32-inch holes, Fig. 9, are then drilled at the points center-punched for a depth of 3/8 inch, through the three 1/8-inch copper disks. The two extra copper disks on the one end are then removed, and the nut turned back in place again, when the seventeen 9/32-inch holes may be continued through the core, using the copper disk having the holes drilled in it as a jig.

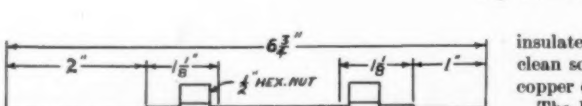


Fig. 11.—Dimensions of Shaft.

The two copper disks which were removed are then bored out to a diameter of 2 1/8 inches and placed on the ends of the core, one on each end, with the holes coinciding with the core holes. For the bars, seventeen pieces of No. 2 bare wire, cut to a length of 2 7/16 inches, will be required. The bars may be inserted bare, but it is best to wrap a thin strip of bond paper around each bar before inserting in the core. The paper may be secured to the bar by means of shellac. The insulation should be trimmed off the ends of the rod, leaving only the center insulated for a distance of 1¾ inches. Scrape the ends clean so that the bars will make good contact with the copper disks which short-circuit them.

The bars are then inserted and riveted down on the end. When the bars are riveted, mount the rotor in the lathe and turn down the outside to 3 3/8 inches in diameter. It is well to work slowly, with a low-cutting speed and a fine cut, because the shaft is so small that the machining is liable to spring it out of true.

To insure the best contact, the bars must be soldered to the copper end rings. A large blunt-ended soldering iron is used with a flux that will make the solder flow freely. The solder should be flooded over the copper bars and end rings. When both ends are soldered mount the rotor between lathe centers and turn off the solder on the faces of the ends down to the copper rings. The slots in which the bars are placed should be opened by a saw cut, two blades being fastened in the hack-saw frame to give a suitable width of cut. The ends of the shaft may now be turned down to 3/8 inches in diameter for the bearings. Provide four vanes, or fans, for each end of the rotor. These fans, dimensioned in Fig. 9, are secured to the copper-end rings by means of small ma-

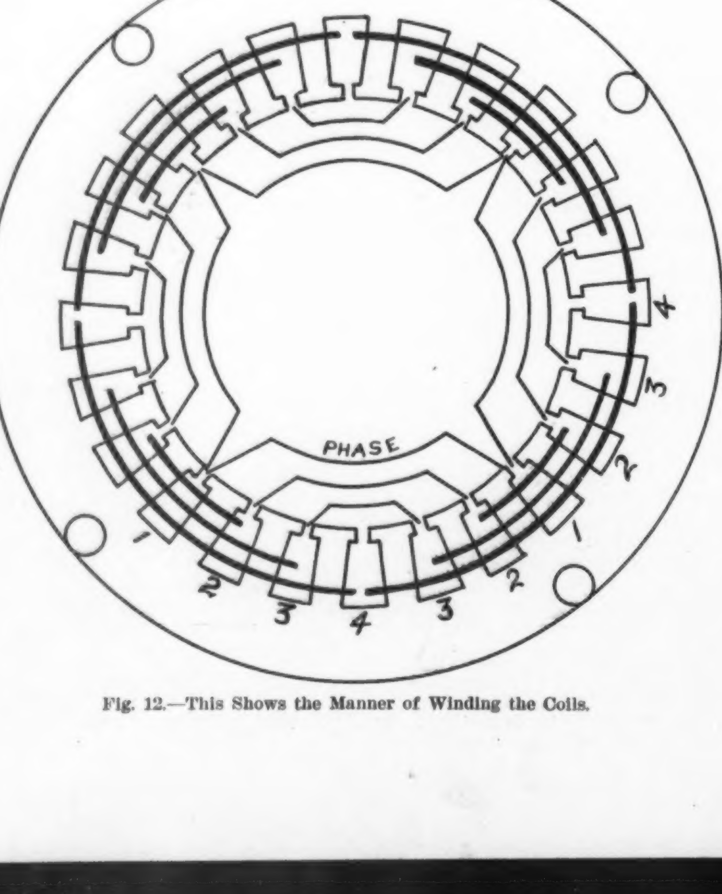


Fig. 12.—This Shows the Manner of Winding the Coils.

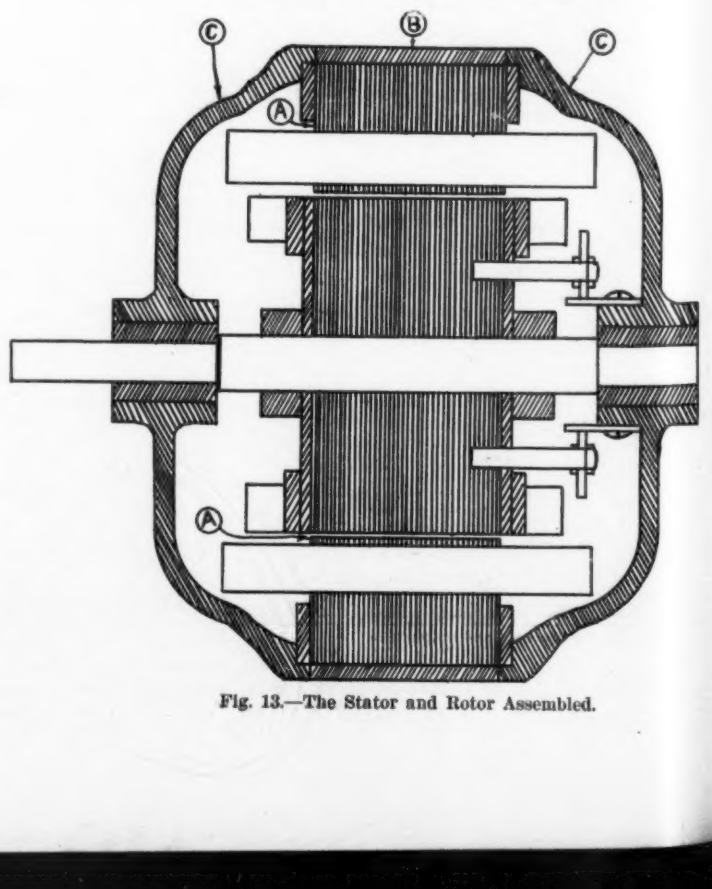


Fig. 13.—The Stator and Rotor Assembled.

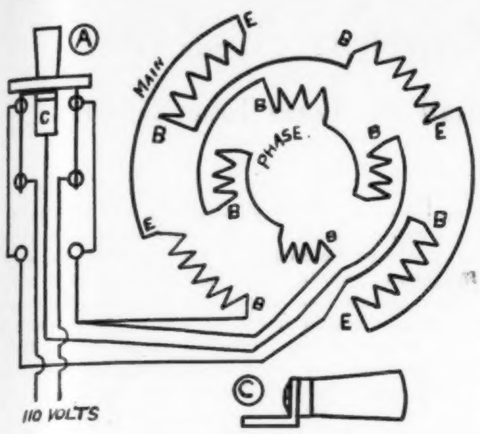


Fig. 14.—Starting Switch.

chine screws in holes tapped for that purpose. It is not necessary to provide these fans, but the machine will run cooler if they are used. The assembled rotor will then appear as in Fig. 10. For the dimensions of the shaft refer to Fig. 11. When the rotor is complete it should be carefully balanced.

With a small file carefully smooth the iron walls of the slots and remove all projections. It will be remembered that while punching the slots no provision was made for opening them at the periphery of the bore. The slots are opened by a saw cut about 3/32 inch wide, made with two or three saw blades fastened side by side in the hacksaw frame.

The slot insulation consists of twenty-four troughs of thin sheet fiber, or tough paper, one for each slot. These troughs of insulation should be long enough to project about 1/4 inch on each end of the core. Each should be dipped in shellac before put in place.

The main winding is wound first. The winding on each pole consists of two and one half coils, each coil containing 52 turns of No. 20 d. c. c. magnet wire, making a total of 130 turns per pole. The coils are wound as in the illustration, Fig. 12. Slot 1 at the center of the pole is left vacant, the first coil commencing in slots 2-2, the second is wound in slots 3-3, and the third or half coil is wound in slots 4-4. Between the parts of the winding on each pole, where they lap on the end of the core, a piece of fiber or other insulation should be inserted. Slots 2 and 3 each contain 52 turns of wire, while slot 4 contains only 26 turns, the remaining 26 turns which fill the slot being supplied by the winding of the adjacent pole. When all four poles are wound the coils should be connected so that if a direct current were flowing through them it would magnetize the poles alternately north and south. If the coils are all wound in the same direction this may be effected by connecting the adjacent coils end to end and beginning to beginning.

The phase coils are wound exactly in the same way except that the coil starts in slots 3-3, continues in slots 2-2, finally expanding into slots 1-1. The phase coils consist of 60 turns of No. 26 d. c. c., divided into three parts. The two inner coils of each pole consist of 24 turns each, and the last coil of 12 turns. The connections of the phase coils is the same as for the main coils.

All connections between coils should be soldered, using a non-corrosive flux, and well taped. The two terminals of each set of coils should have a short piece of flexible lamp chord soldered to it for connection leads.

Referring to Fig. 13 the stator core *A* is put in the frame *B*, the rotor put in place, and the bearing end plates *C* securely drawn up by the nuts on the studs projecting from the stator. The bearing is centered on the stator by the recess in the end plate fitting over the projections of the stator. The machine may then be given a coat of japan or bicycle paint after filling with an iron filler.

For the starting switch *A*, Fig. 14, procure an ordinary double-pole double-throw switch. Remove the handle and fasten a bent piece of sheet copper or brass *C* to the insulating cross piece of the switch by inserting the screw holding the handle through it, and replace the handle. The piece of copper *C* should be connected to the left-hand switch blade as shown. A binding post should be mounted on the switch base in such a position that the contact *C* will make contact with it when the switch is closed. One side of the phase coil is connected to this binding post, and the other to the left-hand switch clip. The main coils connect to the two bottom clips, which are connected to the upper clips by a short piece of wire. The middle clips are connected to the line as shown.

To start the motor throw the switch up. In a few seconds, when the motor has attained normal speed, quickly throw the switch down to the other position. This is the running position. The direction of rotation is changed by simply reversing either the phase or main connections to the switch, but not both. Do not leave the switch in the starting position longer than necessary to start the motor, for the phase coils will heat up and probably burn.

The motor may be made automatic self starting by the addition of the simple device, Fig. 15, which cuts the phase coils out of circuit when the motor is up to speed. The motor may then be started by simply closing the switch. This phase cut-out is composed of two brass contractors *A* sliding loosely on the pins *B*, and rotating with the rotor about the two insulated contacts *C* which are connected in series with the phase coils. The two springs *D* hold the contractors against the contacts, closing the phase circuit until the speed of rotation reaches a predetermined point, when the centrifugal force of the contactors overcomes the spring and opens the phase circuit.

The phase cut-out parts are detailed in Fig. 16. The contact segments *A* are cut from a piece of copper or brass tube *B* and the lug is tapped for a small screw and bent back to the position at *A*. Then cut the tube in two so that there will be a 1/8-inch air gap on each side. These segments are mounted on the inside hub on one of the end plates, which should be turned down smooth to receive it. The segments are insulated from the hub by means of several layers of thin fiber. A 1/8-inch machine screw binds each segment to the hub. Where the screw passes through the segment, the hole should be enlarged to 1/4 inch and a fiber washer should be put under the head so that the screw will not ground the segment.

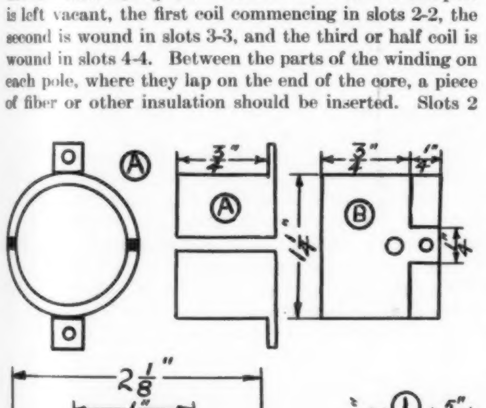


Fig. 16.—Details of Phase Cut-out.

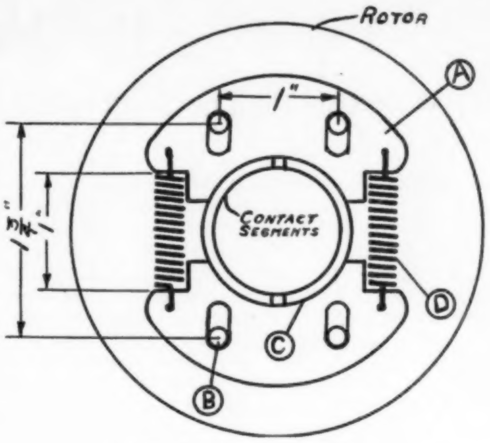


Fig. 15.—Starting Device.

The contactors *D* are cut from some 1/16-inch sheet brass or copper. The slots *E* are 3/8 inches long, made by drilling two 3/16-inch holes with their centers 3/16 inches apart and then cutting out the material between with a small file. Be sure the edge *G* fits the curvature of the contact segments. The screw *H* is made from a piece of brass rod. The nut *I* made of 1/16-inch brass should be turned up to within 3/32 inches of the head, after inserting the screw in the slot in the contractor, and secured with a drop of solder. Then drill and tap the holes for the screws *H*, Fig. 16, in the rotor.

The springs are made by winding No. 22 brass-spring wire around a 3/16-inch rod. Each spring measures 1/2 inch from end to end of the convolutions. The parts should be assembled as in Figs. 13 and 15. The connections of the coils are shown in Fig. 17.

It will be necessary to experiment with the springs until the contactors open the phase circuit at the proper speed which is between 1,700 and 1,750 revolutions per minute. If the contactors open the circuit too soon, try a stronger spring, or if at a higher speed, the spring is too strong, and a weaker spring should be used, or weight added to the contactors in the form of drops of solder.

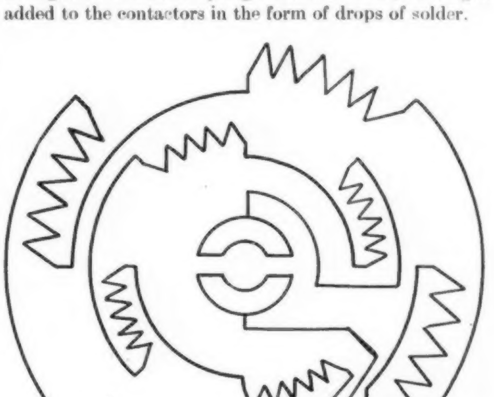


Fig. 17.—Diagram of Connection of Coils.

An Electrical Phenomenon

Mr. A. A. Campbell Swinton communicates the following interesting note to *Nature*.

"The form of high-resistance Bell telephone receiver which of recent years has been evolved for use in some systems of wireless telegraphy, gives us an extraordinarily sensitive means of detecting variable electric currents of a very minute description.

"Using one of these instruments, made by Mr. H. W. Sullivan, which is wound with so many turns of very fine wire that it has a resistance of 5,000 ohms, I have found at my residence, 40 Chester Square, a somewhat surprising state of things.

"Holding one terminal of the telephone in one's hand so as to connect the electrostatic capacity of one's body, and applying the other terminal, which one must be careful not to touch, to any metallic object of considerable size in the house, one immediately hears in the telephone a singing noise. The larger the metallic object and the higher up it is in the house, the louder the sound. The sound is also made louder if one's own electrostatic capacity is increased by contact with another person or with a metallic sheeting. The metal of all the fireplaces gives the sound most distinctly, as does also an iron bedstead on the third floor, which stands on glass castors free from contact with the wall. The sound can be obtained even from the brass stair-carpet rods only about 3 feet long, particularly toward the top of the house, and it can also be got from the gilt of picture fromes. All the curtain-poles give it loudly.

"The position of the object from which the sound is obtained does not appear to matter, excepting that the higher up in the house the louder is the sound.

"There seems to be no question that the cause is some form of electrical induction, or wave, from the electricity supply, which is direct current, from the Westminster Company. That this is so is evidenced by the fact that an exactly similar note can be obtained from the supply mains. The sound appears to be due to a ripple superimposed on the continuous current by the commutators of the dynamos, and at times the beat of the fast-running engines, such as do, in fact, supply the current at certain hours, can distinctly be heard. Furthermore, the phenomenon described above ceases the moment the supply is cut off at the house by opening the double-pole main switch.

"It should be mentioned that on the top of the house there is an aërial, consisting of a piece of wire-netting 20 feet by 4 feet in area, supported on four insulators about 10 feet above the roof, with a wire coming down from this outside the house and entering a room on the ground floor, the whole being destined for use as a wireless receiving station. It is possible that this aërial may have some influence, but the fact that putting it to earth or leaving it insulated does not seem to have the slightest effect upon the results obtained seems rather to point to an opposite conclusion.

"It should, however, be mentioned that with the telephone receiver connected between the wire leading to the aërial and the water-pipe, the singing noise is still very distinctly audible, even after the main double-pole switch is opened, which points to there being a field of force operating on the aërial either from the street mains or from the electric wiring in the neighborhood.

Locating the Friction in Our Transportation System*

Why Our Freight Traffic Costs Us Five Times as Much as National, State and Local Taxes Combined

By R. H. Rogers

COMMERCE and trade, by means of transportation, equalize the potentials between areas of production and areas of consumption though oceans and continents may intervene. The friction or resistance that is opposed to the free flow of commodities has been greatly reduced in the last few generations; so that, at the present time, distances intervening must be very great or the potential between supply and demand very small, to prevent a flow of freight traffic.

The remaining opposing friction may be divided into that of hauling and that of handling. The amount of traffic annually overcoming this resistance is increasing rapidly for two reasons. First, a few generations ago man's wants were few, and were principally supplied by his own efforts or by exchange in his immediate vicinity; while now our wants are very complex, our self-support is indirect, and we make exchange with the whole world. Second, the friction of hauling has been so reduced by the use of great fast steamships in place of sailing vessels, by the improvement of waterways, by the powerful locomotives, large cars and improved roadbeds, that ocean traffic now costs less than a mill per ton mile, and railroad traffic from three to seven mills per ton mile.

The Best We Can Do With Animal Help is a Hybrid With Five Expensive Longshoremen to Load, Unload and Guide Him. Contrast this Combination With the Elephant and One Cheap Mahout, Shown on Front Page

The results of cheap hauling costs may be seen in the fact that nearly fifteen tons of freight are annually chargeable to every individual in this country; and the per capita tonnage is increasing three times as fast as the population. We can look for no further reduction in hauling costs unless some radical, and as yet unthought-of, change is made available.

On the other hand, why does our freight traffic cost us five times as much as our National, State and local taxes combined? Because of the friction in handling. While increased traffic tends to reduce the cost of hauling, exactly the opposite effect takes place at the terminals, where costs per ton are constantly going up. In striking contrast to the swift and smooth passage of a consignment from port to port, or from city to city, is the treatment it receives in the terminals. Here it is subjected to innumerable lifts and lowers, drags and pulls, delays, stoppages and set-backs; until finally it emerges and goes again on its serene way to the ultimate consumer—who must stand the terminal charge.

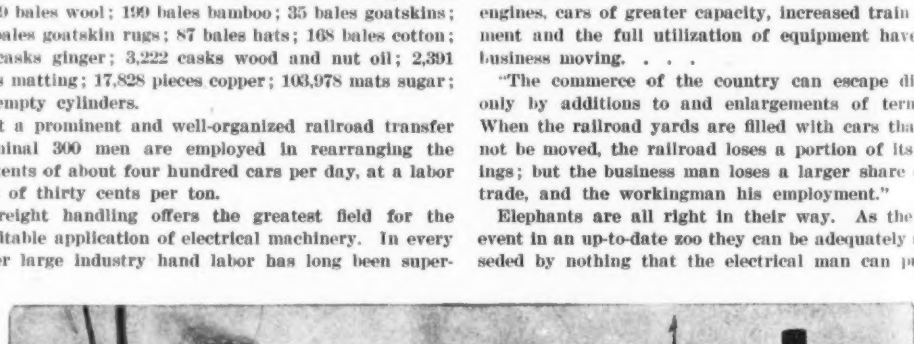
The entire commerce of the world by land and sea must repeatedly pass through terminals with only hand labor to help it over these bare spots. If the losses in the machinery of commerce could be clearly segregated, those chargeable to the terminals would stand out in big figures that, in any other machine, would immediately bring every effort to bear upon their reduction to more reasonable amounts. Facts are stubborn things and bear repeating. The terminal cost in large cities on a given shipment exceeds one thousand miles of hauling cost. With marine traffic the condition is still more marked, for the terminal costs at New York and Liverpool exceed the hauling costs of the 3,000-mile voyage. It is as though a swift and smooth-running vehicle had to be pushed by hand through frequent and increasing sand pits.

Two things are contributing to the rising terminal cost—congestion and a higher wage scale. Expansion of terminals is difficult in large cities—congestion is followed by worse congestion. Wages have increased from \$1 and \$1.25 per day to \$2.50 and \$3.50, while the laborers have depreciated, at least in intelligence. It recently took three hundred men ten days to unload the following interesting cargo from a ship having a standby charge of \$300 per day:

1,327 cases curios; 756 cases bristles; 17 cases hats; 33 cases human hair; 109 cases horse tails; 10 cases oil; 2 cases portières; 10 cases tobacco; 3 cases medicine; 64 cases albumen; 15 cases rhubarb; 500 cases antimony; 140 cases canned crabs; 135 cases crackers; 25,728 cases tea; 14 cases effects; 7 cases pres. ginger; 731 cases groceries; 2,409 bags tea sweepings; 5,980 bags copra; 500 bales cassia; 3,325 bales hemp; 171 bales strawbraid; 116 bales sheepskins; 1,389 bales wool; 199 bales bamboo; 35 bales goatskins; 27 bales goatskin rugs; 87 bales hats; 168 bales cotton; 85 casks ginger; 3,222 casks wood and nut oil; 2,391 rolls matting; 17,828 pieces copper; 103,978 mats sugar; 14 empty cylinders.

At a prominent and well-organized railroad transfer terminal 300 men are employed in rearranging the contents of about four hundred cars per day, at a labor cost of thirty cents per ton.

Freight handling offers the greatest field for the profitable application of electrical machinery. In every other large industry hand labor has long been superseded by machinery; while, more recently, in most cases a second transition has taken place, namely, the application of electric power to the machines themselves. This latter transition has proved profitable to the users. What then of this great industry in which the change can be made in one step from the hand labor of fifty years ago to the highly efficient electric-driven machine methods of to-day?



The Slow and Laborious Distribution of a Ship's Cargo Limits the Speed of Unloading the Ship. This Picture Shows the Overflow from the Piers. Piling Only "Shoulder-high" is the Cause, Since Area is Used Instead of Volume

Because of the tremendous bulk of work, concentrated in space and time, that arises in connection with marine traffic, the handling of ships' cargoes is the phase of freight handling that offers the greatest return on an investment of ingenuity, good management and money. Millions of tons of material are moved every day by the crudest kind of labor. On the docks the human worker reigns supreme, congesting traffic by his complex and cumbersome motions. That such a condition should prevail so long is due to the fact that those most deeply involved "cannot see the forest for the trees." As the superintendent of a prominent terminal in New York Harbor said, "Some time we may do things better, but we have got along a good many years and I reckon we can stand it a while longer. Whose business is it anyway?" Another thing that has maintained this "before-the-war" condition is the more or less intermittent periods of activity at a given pier or wharf and the multiplicity of interests involved in the traffic. The first tends to show a low load factor for a machine and the second spells divided responsibility.

Besides the multitude of existing marine and railway terminals, many new and great terminals are under construction or projected. The Panama Canal will give a great impetus to commerce, making necessary terminals at the canal and at many Gulf and Pacific ports. The New York State Barge Canal is to be equipped with nearly twenty million dollars worth of terminals, of which the State Engineer and Surveyor says: "At all terminals particular attention will be given to freight-handling devices, to the end that the barge canal terminals may excel in this particular and fix the conditions that they may meet."

At this point let us quote from a recent address by James J. Hill, who is fully alive to the location of the friction that is get-at-able in our wonderful transportation systems:

"The figures already given show an increase of traffic in a year about five times as great as the increase of equipment, and eleven times the increase of mileage. Yet the machine has been hauling its load because efficiency has been developed. Heavier rails, larger engines, cars of greater capacity, increased train movement and the full utilization of equipment have kept business moving. . . .

"The commerce of the country can escape disaster only by additions to and enlargements of terminals. When the railroad yards are filled with cars that cannot be moved, the railroad loses a portion of its earnings; but the business man loses a larger share of his trade, and the workingman his employment."

Elephants are all right in their way. As the prize event in an up-to-date zoo they can be adequately superseded by nothing that the electrical man can put up. On the Irrawaddy they may be everything that is good and nice, even in freight-handling. But in the modern American terminal they are most wretchedly and unhappily misplaced. Literally they are not commonly employed in the terminal service of this country. Figuratively, and by analogy, they are. The hand-trucking and hand-piling used to-day are certainly no more efficient than the trunk-method—if as efficient. The elephant's counterpart in the white man's industrial country, i. e., the terminal system which has handed down from generation to generation, is inexcusable and needs reforming.

* Reproduced from the *General Electric Review*

A Typewriter for Music

A Useful Auxiliary for Musicians

To a person not accustomed to writing music the task of producing even a moderately neat copy of music is quite a formidable one. Even the copy written by those thoroughly accustomed to writing music is apt to be more legible to them than to anybody else. There is therefore a good field for a machine which would write music in the same way that an ordinary typewriter writes our common language. A machine of this kind is described in a recent number of the French journal *La Nature*, from which we reproduce the accompanying illustration. It might be remarked at the outset that this machine is not intended to furnish a means for very rapid typewriting, but rather to enable the operator to produce a perfectly neat copy.

As is only natural the machine differs very materially from an ordinary typewriter. In some points, however,

Fig. 1. Fig. 2. Fig. 3.

it resembles the class of typewriters which make use of the typewheel, carrying all the characters upon one rotating drum. This type wheel will be seen in our illustration on the right. Certain characters which extend over the entire staff or even beyond it have to be made in several pieces, thus, for example the violin clef requires four strokes in succession, as shown in Fig. 1; the bass clef on the other hand consists of three pieces, as seen in Fig. 2.

The nature of musical notation makes it necessary to provide means whereby a character may be printed at any one of a number of different levels upon the musical staff. This is accomplished by means of a very simple special device placed at the side of the machine, which itself is constructed just like any ordinary typewriter fitted with a typewheel.

This mechanism, which is shown in our illustration, comprises an axle (see Fig. 4), one end of which is firmly secured to the platen on the typewriter. The other end is provided with a toothed wheel *E'*, engaging with a tooth sector *S*, attached to an axle *B*, which in turn can be rotated through a suitable gearing by turning a handle *M*. It can easily be understood by reference to our illustration that by the aid of this handle the platen can be turned through any desired distance in one direction or the other. In order to guide the operator as regards the distance through which the handle *M* is to be turned, an index *E* is provided, which runs over a graduated slot, and engraved upon the cover *C* of the casing containing the gear wheels These features are shown in a detail drawing inserted in Fig. 4. The graduated scale shows at the center the regular lines of the staff, and above this six supplementary ledger lines, and below it five similar lines. Against these lines are indicated the corresponding notes: in white for the violin clef and in red for the bass clef. The capacity of the machine is 6½ octaves. In order to place the paper at the desired height, all that is necessary is to turn the nut *M* until the index stands opposite the note which it is desired to print.

The lines of the staff are drawn by fitting the index in the desired place and then striking the requisite key repeatedly as many times as it is necessary to reach the end of the paper. Three lines are thus struck at one time; the remaining two are then struck by a second operation. After the staff has thus been drawn, the notes and accidentals, etc., are then written in upon it, using the left hand to manipulate the nut *M* for each character, while the right hand plays upon the keyboard as usual.

It is not claimed that with this machine the same speed can be obtained as in ordinary typewriting. In fact, at best, about the same speed is made as in writing music. The advantage gained, however, is of course absolute clearness and neatness of writing as compared with ordinary manuscript work. The device is intended to enable the composer to prepare a neat copy of his composition at a small cost. By the use of special ink there is no difficulty in preparing a large number of copies from the first typewritten original made on this little machine.

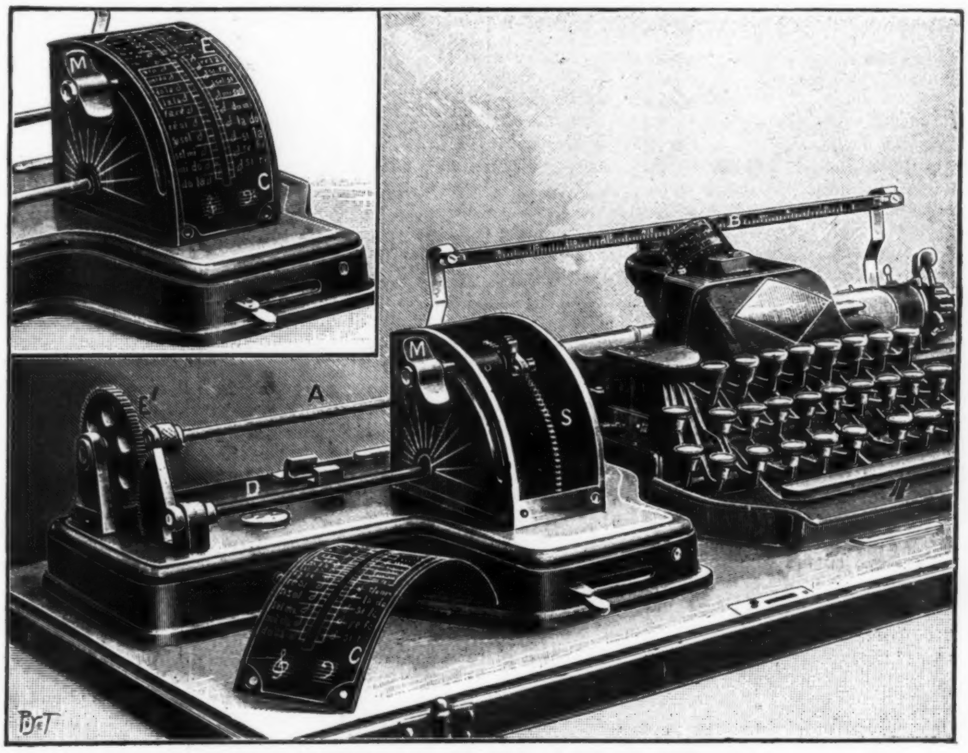


Fig. 4.—General and Detail View of Music Typewriter.

An Electric Dating Stamp

We illustrate an electric dating machine brought out by a German firm and designed to print the date of reception of letters or telegrams in the most convenient and rapid way. It is claimed to be a material aid in the quick handling of business matter. With the usual kinds of dating stamps it is necessary to put the letter into the machine upside down, so that the page cannot be seen while the stamping is going on. The stamp may, therefore, be put on in the wrong place, over printed parts or the like where it cannot be easily read. The new apparatus avoids this disadvantage by placing the type portion in the upper part, so that the letters can be stamped right side up. An electric device is mounted in the base to operate the type wheels and also to give the pressure for the stamping. One of the electro-magnets is connected by wire with a clockwork contact mechanism which gives time signals for hours and minutes. The electro-magnet works the different type wheels by means of a liner which runs up to the wheel mechanism and causes the wheels to advance by a pawl and ratchet drive. Over the type runs a band resembling a typewriter tape upon a pair of rubbers, and the band advances by one step every time the stamp is worked. At the end of its course it is run backward in the same way, so as to give a uniform wear. When the apparatus is in use, the top portion takes a horizontal position just over the soft rubber cushion on the base, so that the paper can be inserted for stamping. The operator uses a foot pedal with electric contact which sends current into a second electro-magnet, and this latter causes the top or hinged stamping part to come down on the paper and make the stamp, then a spring raises it off. The stamp puts on the day, month, and year as well as the hour and minute, A. M. or P. M. To this can be added if desired a permanent stamp showing the firm name, address and the like. All the electro-magnets and their mechanism are enclosed in a stout iron case and are well protected.

An Electric Dating Stamp.

Gain of Definition by Moving a Telescope

A curious observation is reported by M. E. J. Gheury in *Nature*. We quote the writer's own words:

"I am in the habit of rating my chronometer by means of the time-ball dropped at the Greenwich Royal Observatory, about 3⅛ miles away, a signal which I observe in a small hand telescope.

"On March 11th, the weather being misty, I failed to pick the signal post, although I knew exactly where it was, and had placed the telescope exactly in the right direction. I moved the telescope a little, thinking I had displaced it in putting my eye to the eyepiece, and I immediately saw, very dimly, the dome of the observatory, and the signal, with the ball at half-mast, and noticed that *they were in the center of the field all the time*. As soon as I steadied the telescope, however, they vanished completely. They reappeared as soon as I began to 'sweep' for them, but remained discernible only while the motion lasted. I repeated the experiment several times; the signal was really invisible while the telescope was fixed, but by imparting to it a slow oscillation right and left I kept the signal in view with sufficient distinctness to see the ball drop, although I was not certain it had really dropped until a second or so afterward, owing to the great faintness of the image observed.

"I recollected then that, often, in similar conditions of seeing, having picked the signal without any difficulty *while 'sweeping' for it*, I had failed to see it afterward, and gave up the attempt, thinking I had been mistaken, or that the mist had become thicker. I have therefore no doubt as to this most curious and inexplicable fact; an indistinct object is better seen in a slowly moving telescope than in the same telescope when kept steady."

Knowledge and Morals

Ignorance One of the Most Fruitful Sources of Vice

By V. Jefferson Watts

ELLEN KEY, the famous Swedish writer, in her masterpieces "Love and Ethics" and "Love and Marriage," claims that to the loveless marriages, to the narrow, medieval conventionalism of society that condones such marriages and places the ban of socal ostracism upon the unfortunate woman who through love has become a mother out of wedlock, and at the same time gives social recognition to the man, the fellow participator in the crime, and to those individuals who console themselves with the baser substitutes for love, to all of these are due the distorted social conditions and evils of the present day.

She furthermore claims that, inasmuch as sex instinct is the primal force in life about which all other forces revolve and on which all issues depend, all forces, such as will, judgment, reason, as well as all issues, even society, should subserve to the sex instinct. Then there will be no more unhappy marriages, no more divorces, no more social evil; then will it be possible to create a more highly developed race of human beings. In other words, when soul mate finds soul mate, mutual recognition taking place by reason of the sex instinct, then must society and the Almighty recognize such a union, in spite of the Seventh Commandment, that a more perfect race may be created.

"Love can exist without marriage, but marriage cannot exist without love." She maintains that she does not advocate "free love;" that her philosophy is the mean between the two extremes of the loveless marriage, legal prostitution, and free love, illegal prostitution. She insists that her philosophy requires no ceremony to make love lasting, for the fetters of her philosophy are more binding than any words pronounced by a minister of Christ, because her philosophy permits of but one supreme love in a lifetime.

Ellen Key may truly be classed as the propounder of a philosophy which, though secretly believed in and followed by the more daring of womankind and always advocated by certain types of men to gain their ends with women since the beginning of time, would make Socrates, the founder of philosophy and likewise of the purest code of morals after Christ, turn in his grave!

In her attempt to reveal woman's nature, in her endeavor to find a remedy for the sex evils of the age, in her effort to adjust woman to the changing conditions and yet not have her efface herself or her God-given duties in her own sphere, Ellen Key has offered this love philosophy to perplexed woman as a solution for her own problems and incidentally for those of man, and she has offered society an immoral and most decidedly impractical panecea for its ills. To meet these changing conditions, woman's chastity must undergo a revaluation, and this revaluation is nothing more nor less than old-fashioned adultery, for the sole purpose of gratifying the sex instinct, even as do the beasts of the field. Ellen Key has not offered her disciples any other crown of glory here—certainly none in the hereafter—than transitory physical happiness—there could be no mental or moral; and as for compensation for the loss of their own self-respect and the respect of their fellow beings, to say nothing of that of a Higher Power, evidently they are left to work out their own salvation.

If the mother of Alexander Hamilton had voiced her inmost thoughts before she died, would she have said that the revaluation of her chastity compensated her for all that she gave up? Here was a woman who, according to the laws then extant in the West Indies, could not be divorced. She loved this Hamilton and he loved her and they lived together as man and wife—"one supreme love in a life-time," according to Ellen Key. He was an ideal lover but he did not prove an ideal husband. The prosaic of life entered in upon the love dream, as it always has and always will, and the result of their awakening to the commonplaces of life was the shattering of their love dream, and man-fashion, Hamilton left the woman he had seduced to bear the brunt of the disgrace alone. And here is one great flaw in Ellen Key's philosophy—she does not take into account the practical, everyday side of marriage, she deals only with the ideal; and she also overlooks the fact that after the first few weeks or months of wild abandon, this same practical element becomes predominant; she also ignores the fact that, whereas passion generally endures throughout married life, love does not, unless fed by the constant fires of variety, congeniality and mutual understanding.

If the victims of Aaron Burr could speak, what tales of anguish and sorrow would they not reveal! And yet they revalued their chastity, according to Ellen Key!

Dolly Madison, in the "First Lady of the Land," shows that she values her chastity too highly to intrust it even in wedlock to a libertine. And yet her love for him would, in Ellen Key's estimation, have justified her in marrying him. Here is another flaw in her philosophy—she does not take into consideration the fact that men must be fit to assume the responsibilities of marriage and parenthood, if a more highly developed race of human beings is to be created. Dolly Madison had strength of character enough to make physical attraction subservient to judgment, because she knew that she did not dare to intrust herself and her probable offspring to a *roué*. In other words, she had the "betterment of the species and the good of humanity at heart as well as her own happiness."

That there are so many loveless marriages, so many disappointing ones, so many divorces and so many affinities, shows that there is something radically wrong with the system of marriage; but the fault is not in the institution itself, it is in the woeful lack of preparation and education, mental, moral and physical, of the contracting parties. And those who are directly responsible for the present chaos are the parents, for bringing up their children in ignorance, and indirectly the state for allowing all sorts of promiscuous and unregulated marriages. But in spite of the chaos, there is a way out that will eventually lead to peace and order in the state marital. However, this way does not lie through the destruction of marriage as an institution, as Ellen Key would have us believe, but in the preservation and upbuilding of this sacred institution through education.

By making sex instinct the controlling force in life instead of reason and judgment, by placing the sensual above all moral and social obligations, Ellen Key is not only not solving the sex problems and eradicating the sex evils of the age, but she is paving the way for a more licentious free love than we have at present

Enlarging the scope of any evil can never eradicate that evil nor even lessen it, any more than the willful spreading of a disease can check the ravages of that disease. Neither will it help matters to call that evil by another name for the purpose of gilding it. The only way to circumvent any evil is (1) to get at the underlying causes; (2) to make a careful study of the conditions that engender such an evil and cause it to flourish; (3) to eradicate the obnoxious conditions; and (4) to supply a practical and effectual remedy.

The cause of the sex evils of the present day is not, as Ellen Key would have us believe, the ignorance of the existence of passion, or sex instinct, or of its primal purpose, but the causes are (1) the ignorance of the difference between love and passion; (2) the inability to control this force passion, so that love, which is passion regenerate, may come into its own; (3) the ignorance of the elements of real love that must be the foundation of any lasting marriage, such as respect, congeniality, etc.; (4) the ignorance of the mental, moral and physical requirements that are necessary for the happiness and well-being of all who contemplate matrimony and parenthood; (5) the ignorance of the importance of the prenatal period in molding the disposition, features, character, of the prospective child and future citizen; (6) the ignorance of the care of the child and its proper bringing up; (7) the ignorance of the derogatory influence, mentally, morally and physically, of hereditary taints of insanity and sexual diseases upon the offspring, even unto the third and fourth generation.

The conditions which engender these evils and cause them to flourish are (1) the unwillingness of parents to assume the responsibilities of parenthood and instruct their children in the meaning of life and in all matters pertaining thereto, instead of letting them pick up their information on the streets, in alleys, or in even more objectionable places, from all sorts of malicious sources, thereby causing them to get a distorted view of life and placing them in the way of every kind of moral danger; (2) the false modesty and fear of criticism that keeps teachers, superintendents and school boards, especially in the smaller cities, towns and villages, from insisting that graded courses in sex hygiene, scientific mating and parenthood be a part of every school curriculum from the kindergarten to the senior year of high school—the course in sex hygiene used in some of the high schools, while it is a step in the right direction, is by no means comprehensive enough; (3) the prudishness or thoughtlessness of otherwise public spirited citizens that prevents their urging through their respective congressmen and assemblymen laws that will provide for comprehensive and compulsory sex instruction in all State universities, public and parochial schools and an additional course for parents; (4) the indifference of city, State and Federal governments toward the future welfare of citizens and nation, by not taking the initiative in providing laws for the temporary control and ultimate prevention of the social evil, the marriage and divorce evils, and the diseases attendant upon these evils; (5) the lack of co-operation between the churches in regard to these evils and their lack of provision for warding them off; (6) the hesitancy on the part of religious institutions and organizations generally, to add a course in sex hygiene to their religious curriculum; (7) there are no courses in the science of life in our higher institutions of learning; (8) there is no Department of Eugenics at Washington to demand certain standards for qualification for matrimony; to provide for universal education so that these standards may be attained; to provide medical attendance in all vice districts in all localities until such districts can be entirely eliminated; to investigate the economic causes for vice and to eradicate them; to put an end to the white salve traffic as England is doing; to institute State matrimonial bureaus on the French principle, with an added department for fallen women, and also one for the control of sexual diseases on the German principle; to force pre-marital medical examination in every city and State in the Union; to establish a single standard of morals by providing severe laws for the masculine offenders; to make race breeding a matter of scientific importance and national issue as is the case in some of the leading countries of Europe.

These obnoxious conditions can be eradicated and the evil greatly lessened, if the intelligent people, irrespective of class, creed or politics or nationality, will unite in a nation-wide crusade, well organized and co-operative, against these conditions. The ensign of this crusade must be knowledge, and the weapons universal education in the science of life, and these weapons must be wielded by government, clergy and laity. Marriage must no longer be considered a haphazard state of deliverance, but a business into which both parties must put the best they have in health, morals, love, responsibility, etc., so that the profits, happiness and noble offspring may be the highest possible—an institution with a firm economic basis together with lofty ideals, which can only be preserved as its participants are duly qualified mentally, morally and physically. The knowledge of the science of life—or how to be born, how to grow up, how to love, how to marry, how to create and how to rear—will provide this qualification, just as it will cure the sex evils and distorted conditions of the age.

"Knowledge is power and power is life!" Never was there truer maxim and never did maxim more aptly fit the case in hand. It was the knowledge of the ancients that made possible the almost universal tendency toward education in science and the arts in this present day, and it was the knowledge and perseverance of the few that eventually lifted the veil of ignorance of the Middle Ages and paved the way for modern achievement; and it is the knowledge of the scientists and students of humanity regarding the awful consequences to individual and nation of these unchecked sex evils that is arousing them to the necessity of providing a practical and lasting cure for these sex evils as the root of all other evils; and it will be knowledge, discriminate at first because of prejudice, and gradually universal, as these narrow prejudices are overcome and the Science of Life takes its rightful place in the home along with the other moral and material guides that properly belong in man's household, that will make woman value her chastity too highly to become a mother out of wedlock or to intrust it in wedlock to a libertine, fit or unfit. It is knowledge that will eventually put the ban of social ostracism on the double standard of morals, a process already begun in Queen Mary's Court; it is also knowledge gleaned from the pages of science of life that will reveal to man the important relation of the trinity, mind and body and soul, to matrimony, which is virtually the mental, moral and physical union of one man and one woman in holy wedlock for the purpose of continuing the race; and it is this same knowledge that will make possible the conservation of energy of both sexes for the entrance into "the most holy thing in nature," marriage, and through marriage, the creation of a perfect race of human beings. It is knowledge that will teach man to choose his mate, not by the sex instinct alone, but by love, of which sex instinct is a part, plus congeniality, wherein respect and morals shall also have their say. It is knowledge that will give man a realizing sense of the necessity of a proper mental, moral and physical condition at the time of generation—for the child is the instantaneous photograph of the condition of the father at this time—and it is knowledge that will compel woman to give heed to her mental, moral and physical condition during the nine

months of pregnancy and to use her judgment in regard to all outside influences that are brought to bear on her at that time, and also in regard to her own thoughts and desires— for great statesmen, lawyers, musicians, artists, are not so much a matter of coincidence as they are the direct result of painstaking and unceasing study, determined exercise of will and cultivation of taste during the prenatal period; neither are criminals, drunkards or degenerates so much a matter of chance, heredity or environment, as they are the product of the uncontrolled thought or wish of the mother during pregnancy or of the bestial condition of the father at the time of generation; and cripples and imbeciles are not so much the result of unfortunate circumstances as they are the direct result of an unsuccessful attempt at abortion on the part of the mother. It is knowledge that makes travail safe and almost painless and does away with the desire to practise abortion, which is due mostly to the ignorant fear of women of becoming mothers. It is knowledge that teaches the young mother to care for her baby easily and scientifically; that teaches her that the way to control her child is through obedience and the way to keep this control is through confidence; then when she faces the delicate situation of fitting the girl and boy for marriage and parenthood—her husband also has his duty to perform—her task is lighter and the result more beneficial, and she has then fulfilled her highest obligation to God and man!

It is only the knowledge of the terrible ravages of indulgence on mind, body and morals, and the supplement of mental and physical labor that will enable both sexes to refrain from this vicious practice. It is only the knowledge of the causes, symptoms, means of transmission, and of the number of years necessary to effect a complete cure of syphilis, the suffering entailed by the treatment, as well as the danger of allowing this disease to remain in the blood, both to the sufferer himself and to all those who ignorantly or carelessly come in contact with him, even after a local cure has been effected, that will teach humanity that self-control is of more value to health and happiness than the gratification of desire at the probable price of contracting this dread disease, which leaves its imprint, in the form of scrofula, infantile paralysis and bridgeless noses, etc., on the children of the offender and on his children's children, even unto the third and fourth generation. It is the knowledge of the innocent means of transmission of this disease that will make people more careful in the use of public places and appliances which of necessity must be patronized. It is knowledge that will teach man the secret of longevity and youth. And it is knowledge that will enable man to distinguish real love from passion; that will enable him to realize the potent force of congeniality in keeping down the affinity and divorce evils and in eventually rooting them out. And it is knowledge of this science of life that will finally reinstate the sanctity of the home which through ignorance has been so rudely defiled. It is knowledge that will put an end to the white slave traffic, because heretofore it has been the ignorance of the victims that has made their seduction to this nefarious business possible, either by kidnapping or drugging. It is knowledge that will keep the too trusting and unwary girl from surrendering herself to her lover, or to be more accurate, her seducer, under promise of marriage, because through knowledge she will learn to recognize all such overtures for her virtue as insults, mere tricks to bring about her ruin, and she will come to understand as her knowledge increases that no man seeks to seduce any woman through love, but through passion, and having gained his desire, his former passion turns to hate and loathing because unaccompanied by reverence or respect; and the woman who has fallen a victim to that passion, finding herself abandoned by the man she loved, sinks by degrees, varying according to temperament, to the lowest depths. It is knowledge that will teach both man and woman that to understand love, they must first understand that passion is but an element of love, an atom, but not love entire, even as will, judgment, respect, reverence, congeniality, are elements or atoms of love, and that all of these are necessary to form the sublime molecule, love. Knowledge also teaches man that the road to real love lies through the conquest of passion and that the only road to the happy marriage lies through real love.

Ellen Key's philosophy might do very well for an ideal race of human beings who were pure enough to be above passion or to be without it, but for the all too human race of men and women that inhabit this earth, whose everyday existence is one constant struggle with the arch enemy, passion, and whose success or failure depends upon their subjugation of it, this philosophy is very misleading and impractical. What erring humanity needs is education to enable it to withstand this enemy and to make it subservient to will and judgment. Herein lies another flaw in Ellen Key's philosophy—that sex instinct, which in man or beast is the primitive instinct for mating, and which, untutored and uncontrolled, is primarily a force for evil; this sex instinct she has made the controlling force in life, instead of love, which is the quintessence of controlled passion, and which is the greatest force for good in life.

It seems hardly possible that any philosopher could claim that the sex evils and distorted conditions are due to the lack of the recognition of the potency of the sex instinct, when on every side we see the most alarming and revolting evidences of its unrestrained sway. Alas! it is not the ignorance of the existence of this sex instinct or of the force of it that is the root of all the evils of the present day, and of the distorted social conditions, but the ignorance of the proper control of this instinct and the conservation of it for its rightful purpose. It likewise seems impossible that a philosopher who had the real good of humanity at heart could advocate the "burning of an ideal love into the heart of the youth with letters of fire—to give him real moral strength," and in the same breath advocate the casting off of all moral and social restraint to passion and thus destroy society's bulwark, woman's chastity, and the offspring's protection, marriage. That is but a contradictory philosophy which does not eradicate the sex evils, nor even lessen them, neither does it solve the sex problems, it only enlarges their scope for evil and promises nothing to its disciples but social and moral death! Burn the knowledge of the science of life into the heart of the youth with letters of fire—that will give him real moral strength; and burn it into the hearts of as many of erring humanity as it is possible for institutions, organizations and individuals in their respective jurisdictions to reach, and let the Government burn it into the heart of the nation through a new Department of Eugenics at our capital at Washington!

The love we all pray for, long for and so seldom realize in its fullest measure, is not attained, either because by dreaming of an impossible ideal love we overlook real love, or by thinking that we will never experience real love, we ignorantly or willfully accept its baser substitute, passion, in place of the purer gem. What is it and how shall we know it in contradistinction from its unrefined element, passion?

Love in its highest sense is that feeling of pre-eminent devotion and tenderness, founded on respect, mutual understanding and sympathy, a feeling so pure that it will guard the object of its affection from all physical and moral harm and will endow it with a sacredness which, though allied to the physical, will transcend the animal and raise it to the plane of the spiritual. Such a love could only have for its goal matrimony, and for its ultimate purpose the creation of a perfect race.

"Knowledge is power and power is life!" And the power and the life are within your reach if you will but stretch forth your hand and grasp them, and having grasped them, will you not, in the spirit of mercy that "blesseth him that gives and him that takes, that is mightiest in the mightiest," stretch forth your hand and help to lift the darkness of ignorance and prejudice from the masses that are as yet groping for the light?

A Simple Formula for Computing Gyroscopic Forces in an Aeroplane*

By E. V. Huntington

We shall regard the rotating motor as consisting essentially of a single wheel or disk, whose axle is supported by two bearings at known distances from the center of the wheel.

If the aeroplane is compelled by the rudder, or by a sudden gust of wind, to change its direction of flight, this compulsion may be thought of as due to the pressure of a flat board against the side of the axle, at a point, say, in front of the wheel. As is well known, the axle will resist this pressure on account of the gyroscopic action of the rotating wheel, and will *strive to move off at right angles to the impressed force*, and in so doing, will *strive to carry the whole aeroplane with it*. If the wing surface of the aeroplane is large, this motion will be practically entirely prevented by the resistance of the air, and the result of the gyroscopic action will be the setting up of *internal stresses* in the framework of the machine.

The object of the following formula is to provide a simple means of computing the maximum value of these internal stresses in any given case.

Let a = the distance between the bearings, measured along the axle, in *feet*, and let P = the pressure, due to gyroscopic action, on each bearing, in *pounds*. Then P is given by the following formula:

$$Pa = (0.00034\ \ldots)\,Wr^2Nn$$

where

W = weight of the rotating wheel, in *pounds*,

N = angular velocity of the rotating motor, in *revolutions per minute*,

n = the angular velocity with which the aeroplane is turning out of its path, measured in *revolutions per minute*, and

r = the radius of gyration of the wheel about its axle, in *feet*.

Note 1.—A fair estimate of the radius of gyration can be obtained by a mere inspection of the linear dimensions of the wheel. For example, if the wheel were a homogeneous disk of radius R, then $r = (0.7)R$, approximately; while if all the material were concentrated in the rim, then $r = R$; intermediate cases can be judged by the eye.

Note 2.—The coefficient 0.00034 . . . represents the value of $\pi^2/900g$, where $g = 32$ feet per second per second. If the lengths r and a are measured in *centimeters* instead of in feet, this coefficient must be replaced by 0.0000112 . . . . If r and a are measured in *inches*, the coefficient is 0.000029. . . .

As an illustrative numerical case, suppose $W = 167$ pounds (which is the actual weight of a 50 horse-power Gnome motor), $N = 1{,}200$ revolutions per minute, $n = 5$ revolutions per minute (estimated), and $r = 2/3$ foot (estimated). Then if $a = 1$ foot, we shall have P = about 150 pounds; or, if $a = 2$ feet, $P = 75$ pounds, etc.

It thus appears that under ordinary conditions of flight, the effect of these gyroscopic forces could hardly be serious.

In conclusion, we note the following simple rule for determining the *direction* in which the force P will be exerted. (This rule was first published by the writer in the *Engineering News* for June 21st, 1910. See also the SCIENTIFIC AMERICAN for November 23rd, 1912.)

Imagine the deflecting force (that is, the force which compels the aeroplane to change its direction of flight) to be due to the pressure of a flat board against the spinning axle (say in front of the motor), and *note the direction in which the axle, if rough, would tend to roll along the board;* this will give the direction in which the (forward) end of the axle will tend to move as the result of gyroscopic action—that is, the direction in which the force P will act against the (forward) bearing.

For example suppose the axle is spinning in the clockwise direction, as seen by an observer looking forward, and let the aeroplane make a sharp turn to the *left;* then the forward end of the axle will strive to *rise*. Similarly, if the aeroplane makes a sharp dive *downward*, the forward end of the axle will strive to turn to the *left*.

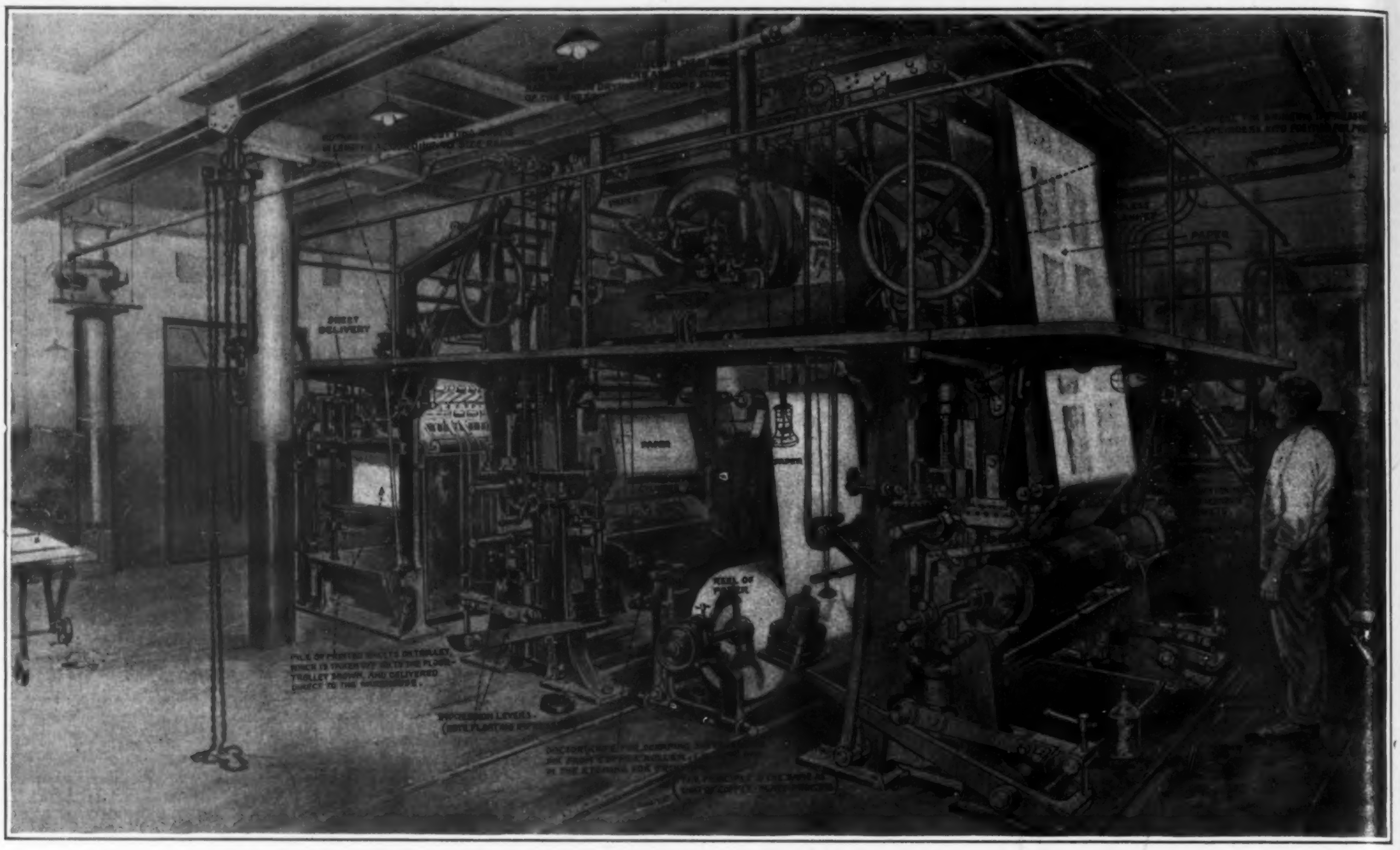
* Reproduced from *Science*.

The Sensitiveness of the Human Eye

Our organs of special sense are far from being perfect, yet the eye, for example, is, all things considered, a very sensitive piece of apparatus. It is interesting to investigate just what is the limit of sensitiveness of our eye. The standard commonly employed in measuring the strength of a light source is the candle-power, a rough idea of whose magnitude may be obtained by remembering that, as the name implies, the light given out by an ordinary candle is approximately one candle-power. The reader will recall that the intensity of light varies inversely as the square of the distance from the source. Thus a light canvas which at a distance of one yard gives a light of one candle-power, will at a distance of two yards give only one fourth of a candle-power, and at three yards one ninth of a candle-power. How far, it may be asked, must a candle be removed from the observer if its light is to remain just perceptible to the eye? The answer is just about one and one half miles. This, on the supposition that the air is perfectly clear, that there are no other sources of light near to disturb the eye, and that that candle has no reflector or any other surface behind it.

In the measurement of light, as in the measurement of almost all quantities with which the physicist is concerned, we can, by employing suitable means, exceed the sensitiveness of the eye. Thus the intensity of light of which we have just been speaking, that given by a candle flame at a distance of a mile and a half, amounting to seventeen one hundred-millionths of a candle-power, while only just perceptible to the eye, can be actually measured with a reasonable degree of accuracy by means of a photo-electric apparatus which consists of a ring of platinum placed in a highly exhausted bulb containing argon gas. Just below the platinum ring the wall of the bulb is coated with a thin layer of metallic potassium. The platinum ring and the potassium film are respectively connected to the poles of an electric battery of about 160 volts tension. A ray of light, however small, falling upon the layer of potassium, causes a discharge to take place between the potassium and the platinum. A sensitive galvanometer introduced into the circuit shows by its deflection the extent of the photo-electric effect.

It is an interesting fact, well known to those engaged in optical research, that the most sensitive spot of the eye is not that at which vision is clearest. Thus if a very dim source is looked at directly, it may be invisible to the eye, but on looking a little to one side of the source, it may still be perceived. We have here the strange paradox that we can see a thing better by not looking at it, than by looking straight into it.



The Rotogravure Machine for the Rapid Reproduction of Topical and Other Subjects by the Photogravure Press.

This machine is notable for a number of reasons: not only does it yield excellent specimens of a very beautiful process, but it turns out the reproductions as rapidly as though they were in the ordinary half-tone, prints both pictures and letterpress at a single operation, and prints both sides of the paper. It runs at three thousand revolutions an hour, and prints the paper in duplicate, which means that it turns out six thousand copies of each subject on an eight-page sheet in an hour. Moreover, it delivers each sheet dry and unsmearable, even at the moment of its leaving the machine. As the drawing shows, paper is fed to it from a roll, and is divided after the impressions have been made by the engraved cylinders by a rotary cutting knife. No "make-ready," or other time-losing work is necessary; immediately the engraved cylinders have been set in place printing can begin. The etching of the cylinders results in a plate which is the reverse of the half-tone, in that the ink, instead of being taken from the top of raised dots, is sucked from recesses in the plate in various thickness, according to the depth of tone required. After leaving the reel, the paper passes over the first engraved cylinder. It is then conveyed round a steam-drum, which dries it. Next, it passes over the second engraved cylinder, and so on.

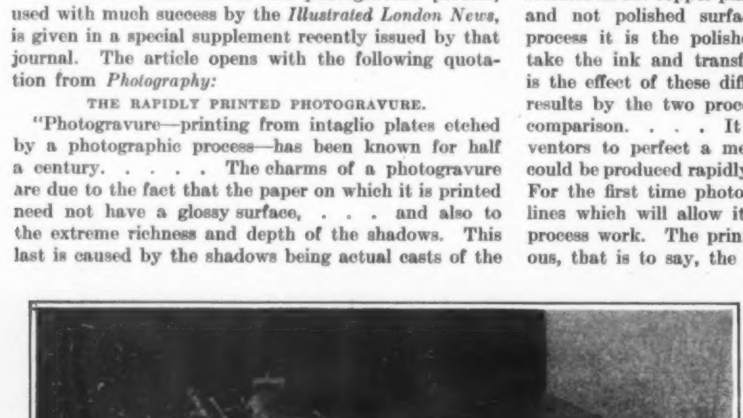
The Rotogravure Quick-Printing Process and Its Possibilities

Speed and Efficiency Gained by Modern Methods

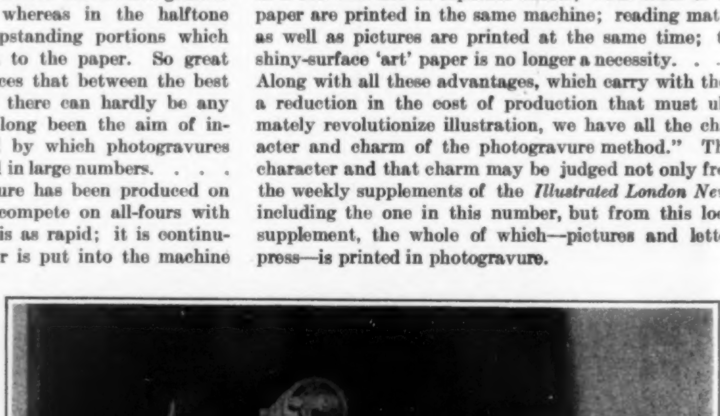
An excellent account of the photogravure process, used with much success by the *Illustrated London News*, is given in a special supplement recently issued by that journal. The article opens with the following quotation from *Photography:*

THE RAPIDLY PRINTED PHOTOGRAVURE.

"Photogravure—printing from intaglio plates etched by a photographic process—has been known for half a century. . . . . The charms of a photogravure are due to the fact that the paper on which it is printed need not have a glossy surface, . . . and also to the extreme richness and depth of the shadows. This last is caused by the shadows being actual casts of the recesses in the copper plate, recesses which have grained and not polished surfaces, whereas in the halftone process it is the polished upstanding portions which take the ink and transfer it to the paper. So great is the effect of these differences that between the best results by the two processes there can hardly be any comparison. . . . It has long been the aim of inventors to perfect a method by which photogravures could be produced rapidly and in large numbers. . . . For the first time photogravure has been produced on lines which will allow it to compete on all-fours with process work. The printing is as rapid; it is continuous, that is to say, the paper is put into the machine in a roll and not in separate sheets; both sides of the paper are printed in the same machine; reading matter as well as pictures are printed at the same time; the shiny-surface 'art' paper is no longer a necessity. . . . Along with all these advantages, which carry with them a reduction in the cost of production that must ultimately revolutionize illustration, we have all the character and charm of the photogravure method." That character and that charm may be judged not only from the weekly supplements of the *Illustrated London News*, including the one in this number, but from this loose supplement, the whole of which—pictures and letterpress—is printed in photogravure.



View Showing the Machine Ready to Print: The Sheet About to be Taken by the Grippers to be Printed; and the Sheet Being Delivered After Printing.



View Showing the Cylinder Raised for the Placing of the Engraved Plate Upon it. This Plate is Clamped Tight by Means of an Expanding Sleeve.

Small Intaglio Sheet-feed Rapid-printing Press, Which will Print Photogravures from Postcard Size to 25 inches by 35 inches.

ADVANTAGES OF THE NEW PROCESS.

The writer then goes on in his own words:

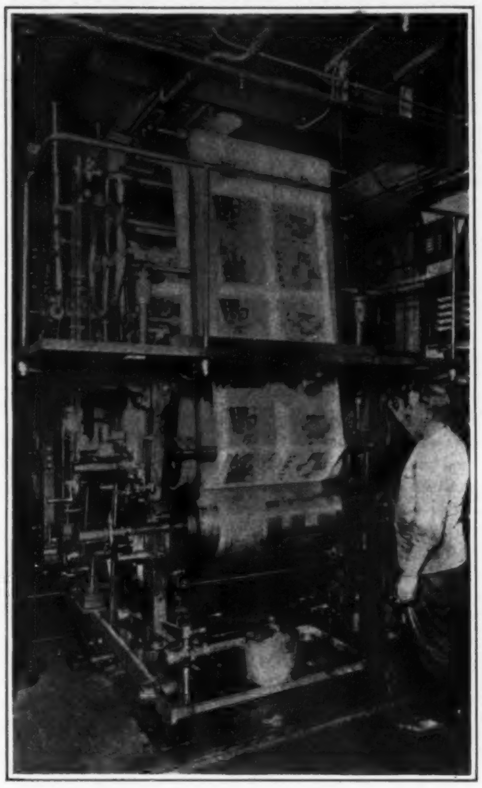
"Now, as to the value of the rapid photogravure process. Something has been said of the excellent results yielded and the speed with which they are attained; let it be pointed out further that anything which can be photographed can be reproduced by it and printed with most artistic effect, with an economy which cannot be equalled, quality considered, by any other system of quick printing. Then, too, the new photogravure method is ahead of the old in that it provides a level printing-surface, made up of just so many cells to the square inch, which means that there can be produced mechanically an intaglio printing-plate so perfect in its finish that it calls neither for retouching by hand nor for elaborate, therefore slow, "make-ready," a point of much importance to the artist this, for it ensures a precise rendering of his work, which is presented without having undergone modification by alien hands. It must not be thought, however, that there is no possibility of making additions and other alterations when such may be required. Were it so, serious difficulties might arise now and again and the commercial scope of the process would be distinctly lessened. Changes may be made, in the customary manner, on the negative, or on the positive made from the negative; even, by the skilful hand of the plate-finisher, upon the engraved copper printing-cylinders. And it must be noted that the cost of the printing-cylinders does not really represent very great expense, for each roller yields a remarkable amount of printing-surface; the etchings are shallow and thus easily and quickly erased to make way for new, once the surface has been repolished; and when its circumference has become too small, the cylinder can be resurfaced in an electro-copper depositing bath. The etching itself, including the letterpress which accompanies it, is done on the printing-cylinder itself in a few hours, and costs very little more than the ordinary halftone. So much for a few of the many points which, added to the charm of the finished product, make it the more remarkable that so excellent a process, the best for high-class illustrations, should have been comparatively unexploited and unused in the past, and should have been so closely guarded as to its details as to be practically unknown to the public, save by results.

ROTOGRAVURE DESCRIBED.

In principle, it may here be remarked, photogravure is practically the same process as that used for wall-paper printing and silk-printing, curious as this may seem at first blush; and, therefore, as regards speed, bears the relation to plate-printing which the perfected newspaper web-press of to-day bears to the old Albion hand-press, while, when quality and cost are compared, it is without a rival. For those unfamiliar with the theory of the silk-printing machine as applied to this process, we may give a very brief description of it. A large iron drum, rubber-surfaced, is brought to bear against the engraved printing-cylinder. Between these two cylinders, one of which is power-driven, passes the paper to be printed. By pressure, the rubber-surfaced drum forces the paper to pick up the ink from the recesses of the engraved printing-cylinder, which has the whole of its surface first covered with ink from a color-box below it, then wiped clean by a steel scraper, which is so placed that it does its vitally important work while at the same time avoiding unnecessary friction and the consequent wearing away of the engraved surface; this inking and wiping takes place at every revolution of the engraved cylinder. The Rotogravure method is that more generally called the carbon, and is the simplest and most practical for the printing of many impressions or few; that is, for what the printer calls a short or long run, a circulation small or large. It has been brought to such a pitch of efficiency that it can be employed for the reproduction of topical illustrations. The surface printed from is the reverse of the half-tone surface. In the latter, the surface is broken up into innumerable dots of various sizes, and the ink is impressed upon the paper by the top of those dots in one thin, uniform layer. In the case of the photogravure the solid black and the tones are set upon the paper by being sucked up from the recesses of the printing-plate, a system which conveys to the paper ink not of uniform thickness, but of a number of thicknesses; thus the full tone-values of the original picture are wonderfully preserved. For the sake of additional clearness, we may compare the halftone block with the rubber stamp of commerce; the raised surface of dots conveys the ink to the paper just as the raised rubber lines convey it; with photogravure the ink is sucked up from recesses representing what is raised in the other case.

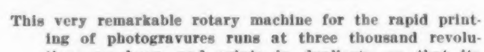
PHOTOGRAVURES IN THE MAKING.

Let us take the procedure step by step. The subjects for reproduction are chosen by the Editor, are scaled to the sizes required, and are then handed to the process-engraving department, with full instructions as to size, date and time of delivery, and so on. Next, the process-engraver, trained in the art and science of photography and mechanical reproduction for printing, goes to work; while the descriptive lines for the subjects are written, are set up by the composing department, and are passed for press. The first duty of the process-engraver is to make the negative. Some might think that the production of a perfect printing-plate depends chiefly upon this, but it does not. For all that, a good, full-timed, "plucky" negative is an essential, and the same may be said of the succeeding positive and negative prints. The making of a photogravure-plate was so well described in the issue of *Photography* already mentioned, that we cannot do better than quote this journal again. In outline, photogravure "consists in giving to a highly polished copper plate a very fine grain. This is done by placing it in a box, or chamber, in which is a quantity of finely powdered bitumen. This bitumen dust is dispersed throughout the air of the chamber, given a few moments for the larger particles to settle, and then the copper plate is introduced and allowed to remain for a certain time in a horizontal position. A very fine dust settles upon the copper, and, the plate being taken out and heated, the bitumen dust attaches itself to the metal. A positive transparency having been made from the negative that is to be reproduced, a print from the transparency is made upon carbon tissue, and this is squeezed down upon the prepared copper plate and developed. The edges and back of the copper having been protected by varnish, the plate is immersed in solutions of iron perchloride of various strengths and etched. When the carbon tissue is thinnest, that is to say, where it has been least exposed to light, which, as it was printed from a positive and not a negative transparency, will be the shadows or darker parts of the picture, the etching-fluid gets through quickest, and so attacks the copper most, and *vice versa*. So that when the etching is finished, and the carbon tissue and varnish are cleaned off, we have an engraved plate, in which the high lights of the picture are formed by those portions which have been least attacked by the perchloride, while the shadows are those which have been most deeply etched." In Rotogravure, the first step that has to be taken to reproduce a picture is to "photograph it, and from the negative so obtained a transparency is made, dry-plates being used for both operations. From this transparency, which is, of course, a positive, a print is made on carbon tissue, and after the carbon tissue has been exposed under the transparency, it receives a second exposure underneath a special form of ruled screen. The printing-surface being a cylinder, and not, as in ordinary photogravure, a flat plate, a cylinder of polished copper, the dimensions of which are governed by the size of the sheet of pictures that are to be printed, is prepared. On this cylinder the carbon tissue is laid down and developed, each picture in exactly the right place on the cylinder for the picture to appear correctly in the finished sheet. Any reading-matter that is to go with the pictures is similarly laid down; and then, the parts that are not to print having been given a coat of protective varnish, the whole cylinder is placed in an etching-fluid, which makes its way with varying rapidity through the different parts of the carbon tissue image, and eats away the copper underneath. When this action has proceeded to the desired extent, the tissue and varnish are cleared off the cylinder, and it is ready for printing." Two separate cylinders are required, one for each side of the paper, if both sides are to be printed. With regard to the actual printing, it may be said that "each cylinder is carried on a horizontal spindle, just above a roller, the lower part of which dips into a large trough of a comparatively fluid ink. This roller spreads a very liberal coating of the ink all over the surface of the cylinder as the latter rotates. Its rotation brings the inked surface against a steel knife (the Doctor), which is drawn backward and forward along the surface of the cylinder. The knife removes the whole of the ink from those parts of the copper which have been left bright owing to the protection of the varnish, or of the 'resist,' during the etching, but it leaves the ink in the hollows of the copper so that when the cylinder in its further travel is brought into contact with the web of paper, which is pressed closely against it, the paper picks the ink out of these etched parts and so obtains its image."

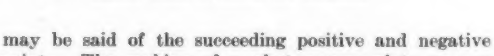


The Rotogravure Machine: View Showing Printed Paper Passing from one of the Etched Cylinders.

This very remarkable rotary machine for the rapid printing of photogravures runs at three thousand revolutions an hour, and prints in duplicate, so that its capacity is six thousand eight-page sheets of photogravure subjects an hour. Each sheet is absolutely dry and unsmearable when it leaves the machine.



A DIAGRAM SHOWING HOW THE SURFACE OF THE PRINTING-PLATE TAKES THE INK IN THE CASE OF HALF-TONE.



A DIAGRAM SHOWING HOW THE SURFACE OF THE PRINTING-PLATE TAKES THE INK IN THE CASE OF PHOTOGRAVURE.

In the case of the half-tone plate, the ink is received, in a layer of uniform thickness, on the upraised dots of the metal plate, just as ink is received on the upraised portions of a rubber-stamp. In the case of the photogravure plate, the position is reversed. The ink is received, in various thicknesses, according to the varying depths of shadows required in the impression, in recesses. The ink is sucked up from these recesses by the paper, which thus receives it, not in a uniform layer, but in a number of thicknesses, a fact which, of course, makes for softness, richness, and depth of tone.

THE ETCHING AND OTHER MATTERS.

The negative and the succeeding positive and negative prints having been obtained satisfactorily, there comes a stage in the work which must be done under precisely the proper conditions, or everything already performed will be nullified. The temperature and the strength of the etching-solution must be exactly what they should be; for the operator, however able he may be, has then little control which will enable him to guarantee a perfect reproduction, the numerous details, tones and qualities desired in the final result being produced mechanically. For that reason the tones and qualities sought must, of course, be represented fully in the carbon "resist" upon the copper cylinder before etching is begun; and, for that reason, it is obvious that a perfect printing-cylinder may most surely be secured by the use of a constant etching-solution which will eliminate uncertainty; let it be emphasized again that if the correct qualities are not present in the carbon tissue on the copper cylinder, nothing that can be done in etching, inking, or printing will save the situation. Imagine for a moment the engraved printing-cylinder, with its many and minute tones, making several thousand revolutions an hour, flushed with ink in a fraction of a second and in that fraction of a second having its surface wiped before it comes into contact with the paper which sucks the ink from its recesses. Remember that the impression on the paper is made up of layers of ink of thickness varying according to the depth of the recesses in the plate. Think what ingenious and smooth-running machinery this means, what delicate adjustment, and what care. Then realize that, as in other photo-mechanical processes, it is in the printing-plate that the quality must be found. The etching must be well understood in theory and in practice, otherwise the result will be failure or, at best, a happy chance. The whole question may be summed up as follows: To etch properly a gelatine print of "resist," being dependent upon its absorbent qualities in exact ratio to the degree of insolubility set up by light in the printing, means simply a knowledge of the relative strength and action of the etching-solution at a given temperature. At any temperature, say between 60 and 95 deg. Fahr., the stronger the etching-solution the slower is its action, and the weaker the etching-solution the quicker is its action upon the gelatine resist. The rest of the work is purely mechanical, a matter of system and rules.

The Structure of the Atom—III*

The Physical and Chemical Properties of the Atom Explained in the Light of Modern Theory and Experiment

By Sir J. J. Thomson, F.R.S.

Continued from Scientific American Supplement No. 1945, Page 235, April 12, 1913

We will continue with the consideration of the first fundamental problem involved in the atmomic theory, namely the determination of the number of atoms in a given weight or volume of a body At the end of my last lecture I described one method of solving this problem which physicists owe to Prof. Perrin, and it may be useful if I recall the fundamental principles on which this method is based. The most important theorem in the kinetic theory of gases is that the ratio of the pressure of a gas to the number of molecules in a given volume is the same for all gases. It is thus the same for hydrogen, a light gas, as for the vapor of mercury, which is the heaviest known. Were it possible to determine this ratio, then from the expression $p=\alpha N$, the value of N could be found for any gas, since α is independent of the nature of the gas. In the above, p denotes the pressure of gas, N the number of molecules in the unit volume, and α the constant in question. If Nature had provided us with a suitable gas in which we could both measure the pressure and count N, we should find α and could then find N for any other gas in virtue of the relation that, at atmospheric pressure, p is equal to 1,000,000 dynes per square centimeter. Unfortunately, Nature has not provided us with a gas having molecules, on such a scale, that N can be determined by directly counting them. Perrin remedied this omission of Nature by producing artificial gases in which the "molecules" are 100,000,000 times as heavy as the molecules of air. With these artificial gases it is feasible to count the molecules in a given volume, and it is further possible to determine the pressure by the method described in my last lecture. Having found p and N, the problem is solved, provided that the kinetic theory can be trusted over so great a range as that between the molecules of hydrogen and a "molecule" 100,000,000 times as heavy as the molecules of air. The only thing that remained, then, was to make sure that this was the case. If the kinetic theory could be trusted for this range, α should come out the same, whatever the particles used by Perrin, whether they were of gamboge or of mastic, and this was found to be the case. Perrin also varied the liquids in which his particles were suspended, and again got the same value of α. He thus felt justified in concluding that his emulsions acted as gases, "within the meaning of the Act," and that his value of α, thus found, would "fit in" with any other gas. The difference of scale between his artificial gas and ordinary gases may be illustrated by the fact that it was necessary to go up as high as the top of the Matterhorn before the atmospheric pressure is reduced to one half its value at sea-level. In Perrin's artificial gases a rise of 1/20 millimeter (1/500 of an inch) was sufficient to halve the pressure.

From Perrin's results it appears that N, the number of particles in 2 grammes of hydrogen, or in 32 grammes of oxygen, or, in short, in a "gramme molecule" of any gas, is

$$N=6.83\times10^{23}.$$

It is impossible to convey any idea of the vastness of this number, but a million $\times$ a million $\times$ a million $\times$ a million is equal to 10^{24}.

Perrin's method is the most direct one yet devised for determining this fundamentally important constant; but, historically speaking, it is not the first in the field. The earlier method depends on finding the charge-carried by the ions of an ionized gas. There is a very simple relation, which I shall give in a later lecture, between this charge and the value of N. As for the methods used to determine the charge carried by each electrified molecule, I shall only be able to set forth the general principles on which the method is based, and can not go into details as to the precautions necessary to get satisfactory results.

Suppose, then, that a pair of parallel plates are arranged in a closed vessel, the gas in which is ionized by Röntgen rays or otherwise. Then by establishing a strong electric field between these plates the positive ions are caused to go to one plate and the negative to the other, and the total charge carried can be measured without difficulty. This, however, is not what was wanted, which is the charge carried by each particle. To determine this charge it is necessary to count N, the number of electrified particles, and this constitutes a much more difficult problem. The method used depends on the fact that if damp air containing electrified particles is suddenly cooled, each particle becomes the nucleus of a drop of water, the mixture of moisture and electrified particles settling down as a fog.

[To illustrate this fact, Prof. Thomson threw on a screen the shadow of a jet of steam issuing from a nozzle into the air. The nozzle was coupled up to a Wimshurst machine, and he showed that whenever the latter was operated the shadow of the jet became very much blacker than it was when the nozzle was unelectrified, the increase of blackness being due to a further deposition of water from the vapor.

Prof. Thomson next showed that if a red-hot iron ball were brought near the jet, there was again a blackening of the shadow. In this case he pointed out that the high temperature of the ball would of itself tend to diminish the condensation and render the shadow fainter; this tendency was, however, overborne by the fact that such a red-hot ball emitted negatively-electrified particles which served as nuclei on which condensation took place. He also showed that a slight darkening of the shadow was produced by letting the fumes of nitric acid enter the jet.]

Reverting to the method used for counting the ions which carry the charges between the parallel plates mentioned above, as stated, this mixture of positive and negative ions could be converted into a cloud by having the air in which they are suspended saturated with water vapor. If such air is cooled suddenly, it can no longer carry the same amount of moisture in suspension; and if one knows to what temperature it was cooled, the weight of water deposited can be determined. It is well known, for instance, how much moisture air can carry when at a temperature of 15 deg Cent., and also what weight will saturate it at a temperature of 2 deg Cent or 3 deg Cent. If these were the initial and final temperatures of the air in the experiment, the difference represents the weight deposited on the particles to form a cloud. The most convenient way of cooling the air through a definite range of temperature is to expand it suddenly. This method is in principle the same as that by which air is liquefied in commercial work, by expanding it down from a very high pressure. Conversely, a sudden compression of the air will heat it. Although this effect is somewhat abstruse, it is one of the most remarkable facts about savage races that two distinct and independent tribes have discovered and perfected a method of getting fire by the sudden compression of air. The experiment is by no means easy to execute in a laboratory, and it is very difficult to conjecture the process by which these savages have been able to discover the method.

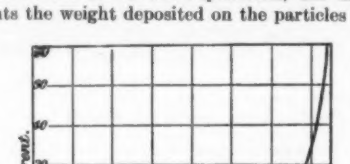


Fig. 1.—Increase of Conductivity with Field Intensity.

The cooling consequent on a given range of expansion is easily calculated, and from this the weight of water forming the cloud. If the size of each droplet in the cloud were known, the number present was readily obtained. The size of the droplets can be deduced by measuring the rate at which they sink down through the air. As the number of electrified particles is equal to the number of droplets, and the total amount of electricity carried is known, the amount carried by each is finally ascertained.

Knowing the charge carried by each electrified particle, it is possible to deduce the number of molecules present in a gramme-molecule of a gas. The value of N thus found comes out as $6.8+10^{23}$, which is practically identical with that found by Perrin, though no two methods could be less alike.

A third method of finding N has become possible since the discovery of the radioactive particles. It depends on the fact that these groups of radioactive elements give off the so-called α particles which carry a positive charge.

If these particles are directed into a metallic vessel, they give up to this vessel their charge, and the total charge can thus be easily ascertained. If the number of particles can be counted, the charge on each can be found, and from this, as before, the value of N determined. The number in question has been counted in two different ways. In the first, advantage is taken of the fact that when an α particle strikes against a suitable screen a phosphorescent spot was produced, as evidenced by the spinthariscope. In this instrument a very great number of such particles are given off, and the whole screen is covered with twinkling stars of light. By cutting down the amount of radium used, however, the number of impacts can be reduced to two or three a minute, and these, of course, can be counted. This enumeration had been made by Dr. Geiger, who thus determined the number of α particles given off per hour by a known weight of radium.

Hence, by measuring the total charge emitted in the same time, the charge carried by each particle can be determined. The task of counting the spots is by no means an easy one, involving the fatiguing work of sitting for hours in a darkened room and recording each faint appearance on the screen. Even the most careful observer might be expected to nod occasionally, and it was therefore important to get some other way of counting these particles which did not involve the personal factor. This has been effected by Rutherford in a very ingenious manner. He arranged matters so that the α particles were discharged into a space between two parallel plates, which were connected to opposite poles of a battery. When an α particle rushed into the gas between these plates, it split up the molecules encountered into positively and negatively ions, thus for the moment rendering the space, between the plates, a conductor, and an instantaneous current resulted. Were this current big enough to be registered by a recording galvanometer, the discharge of each α particle would be registered by a kink in the trace. Though each α particle produced some 94,000 ions before its ionizing power was exhausted, this was not quite enough to operate a galvanometer, being just on the verge of what was measurable.

Rutherford therefore multiplied the effect of each α particles by making each ion itself the parent of an enormous number of other ions. This he did by establishing an enormous electric field between the two plates. This field gave the ions such a velocity that they were themselves capable of producing further ions. In this way Rutherford magnified the effect of each α particle, so that it could be automatically registered by a recording galvanometer. The increase of conductivity consequent on an increase of the electric field is well shown by Fig. 1, where it will be seen that the current shot up very rapidly when a certain intensity was exceeded. In this way Rutherford obtained the following value:

$$N=6.2\times10^{23}.$$

A modification has been made by Dewar, who determined how much helium was produced in a certain time by a stated weight of radium. Since helium is nothing but the converted α particles, the amount of helium is equal to the quantity of α particles, and in this way Dewar got $N=6.4\times10_{23}$, and the same figure is given by a method based on the theory of radiation.

All the values found are, it will be seen, in good agreement, and we have thus much confidence that we do know with considerable accuracy "Avogadro's constant," which is the number of particles in a gramme molecule of a gas. The number of molecules in a cubic centimeter of a gas at atmospheric pressure and at 0 deg. Cent. is $2.35\times10_{19}$.

By the above methods a complete census has been obtained of the number of "systems" present in a given weight of a gas, and I shall now pass on to discuss a more difficult problem—viz., to find the population of the individual atom. I have shown that from each atom negative particles can be obtained, and it is important to know how many of these corpuscles there are present in each case Such a census constitutes, however, a much more difficult problem than that of counting the molecules. At a previous lecture I have shown that in the case of mercury it was possible to remove as many as eight of these corpuscles from the atom, and in this case, therefore, the total number present must be considerable. Two methods have been employed to find the corpuscular population of the atom. One of these is dependent upon a certain property of the Röntgen rays. If a cathode particle is suddenly started or stopped, it gives rise to Röntgen rays. We know that these rays are a form of electric wave quite analogous in its nature to light. If such rays are allowed to fall on a corpuscle, they set it in motion, and this corpuscle itself then produces Röntgen rays on its own account. The rays thus

* The third of a series of lectures delivered by Sir J. J. Thomson at the Royal Institution, London, and reported in *Engineering*.

given off by a mass of gas could be measured, and it is known that they are practically entirely produced by the negative particles, since the positive electricity in the atom is so heavy and big that it is not moved enough by the incident rays to generate fresh rays on its own account. The secondary radiation comes, therefore, wholly from the negative particles.

A connection has been found between the intensity of this secondary radiation and the number of negative particles present. Barkla has measured this intensity, and thus deduced the result that the number of negative particles in a molecule of a gas is proportional to the atomic weight. It is thus sixteen times as high in oxygen as in hydrogen, and 200 times as much in mercury as in the gas last named. The ratio between the number of particles present and the atomic weight is not a large one, the number of corpuscles present in the atom being between two and three times the atomic weight.

An objection to the above method of making the estimate is that if any of the negative particles were held in the core of the atom by very strong forces, the incident radiation would be unable to set them in motion, and these particles would, therefore, not be counted, which would result in too low an estimate of the corpuscles present. Another method has therefore been tried in which the importance of such firmly-held corpuscles is exaggerated. A negative particle, if shot through an atom, would be deflected by each corpuscle it came near. This deflection would sometimes be to one side and sometimes to another, but the sum of these deflections would not generally balance, just as, if a coin were tossed up 1,000 times, the total number of heads and the total number of tails would practically never be exactly equal. Hence a cathode particle passing through a collection of negative particles would not, on its final exit, be found to be moving in exactly the same direction as it had originally. A fine pencil of such rays would thus be rendered fuzzy by such a passage and come out as a sort of brush in place of as a parallel pencil. By measuring the spread of the brush, it is possible to calculate the number of particles which have acted. This method, as stated, will exaggerate the importance of firmly-held particles, since these will not "give," as the cathode particle rushes past them, and a weak point in the Röntgen ray method, of arriving at the number of particles present, is thus made good. Estimated in this way, the result is again that the number of particles present in the atom is between two and three times the atomic weight, and this is about as far as it was now possible to go.

Even so limited a population as this, however, gives rise to some intricate problems. In mercury there must be at least 200 particles present, all repelling each other, so that the problem to be faced lies in discovering in what conditions they would be in equilibrium. Hints for its solution may be obtained by experiment, and these experiments have an important bearing upon the significance of what chemists termed "valency." In these experiments he uses little magnets to represent the negative particle These consist of needles, each run through a fragment of cork so that it will float. By arranging that poles of the same kind are in all cases at the top, these magnets will repel each other if a number are placed in a basin of water; but by arranging over the center of the water a powerful pole of suitable sign the floating magnets will be attracted in, and arrange themselves in states of equilibrium.

Thus three floating magnets will arrange themselves at the corners of a square, and five at the corners of a pentagon On adding a sixth, however, the set does not form a hexagon, but a pentagon with a single magnet at the center. With this magnet in the center, the addition of another magnet will lead to the formation of a hexagon with a central magnet, and a ring of seven is also stable, with one magnet at the center. The addition of still another cause, however, a second magnet to pass to the center. The sudden changes in the grouping which occur at certain critical numbers, when additional magnets are added, throw a good deal of light on the question of valency, and with this I shall deal later.

(*To be continued*)

Some Indirect Causes of Imperfect Interchangeability*

The Fit of Machined Parts Often Disappointing

By A. Whitehead

Much attention has been given to the establishment of systems of tolerances or limits of error in machined work during recent years, with a view to obtaining interchangeability and to reduce the amount of handwork. The utility of such systems for this purpose is obvious, and many have been invented and employed with more or less success. But when it is considered how accurate the product of our modern machine-shop appears to be when tested in the usual way by limit-gages appropriate to the particular tolerance system in use, the amount of subsequent adjustment frequently found necessary in the fitting or erecting-shops must seem extraordinary. Ingenious and expensive appliances are made in order that interchangeable work may result, yet the outcome may be disappointing in that respect. Clearances cannot be exaggerated in high-class work; moreover, the interchangeability, to be perfect, should be of that degree when parts will not only assemble, but will run well together without any alteration or selection. This condition is attainable, for it has been reached in certain branches of manufacture, branches somewhat removed, however, from ordinary engineering practice by reason of the size and quantity of the evolved product, which enable special manufacturing means to be adopted. Such means must have been wisely chosen and consistently employed to be successful.

There is rarely need for intricate or elaborate methods, although these are sometimes justified. An exact knowledge of the function of the piece to be made, governed by common-sense, will often enable the very best quality work to be produced—though not very expeditiously, maybe—with the aid of special tools, few in number and simple in character. At the same time parts may be made with the aid of a most elaborately equipped plant which, although they pass inspection readily, do not deserve to do so, and could not under a better system. The more searching tests of assembling or running will reveal faults: rotating pieces will not run true, or parts will fail to align or to match, until some adjustment is made. The causes are always to be found on investigation, but, unfortunately, an inquiry is rare, because the magnitude of the defect in any particular case is seldom large enough to force one. Besides, it appears absurd to suspect any defect in machinery which is known to be correct within a very minute fraction of an inch; it is easier to attribute it to some unknown evil influence. With the exception of certain aspects, such as cost accounting, card systems, and the like, the science of manufacturing has received an unjustifiably scant attention from educated engineers. A few weekly papers are devoted to the subject, it is true, but on the whole the treatment is far from what it ought to be. There is a real need for men who can arrange and direct manufacturing processes in just the same manner that design is controlled by the drawing office; that is, minutely to the smallest detail, yet with breadth of judgment and certainty. But such men as have acquired that almost instinctive perception of difficulties and troubles likely to attend certain procedure which comes from long shop experience, rarely have had the advantage of undergoing the discipline of a good education and training in physical science. They have instinct with little understanding or powers of expression. On the other hand, the man of limited shop experience, and therefore superficial knowledge of processes, is frequently superabundantly blessed with powers of expression. His efforts to direct will result in delay, expense, and ill-feeling, until in time his knowledge increases, or, crushed at last, he meekly yields entirely to the shop foremen. The right man will rapidly become guide and counsellor to foremen and draughtsmen too. His rule over shop processes will be absolute, but not despotic. What follows illustrates the kind of trouble he will constantly have to meet and overcome, anticipating when possible all manufacturing needs.

Everybody knows that turned work is never symmetrically disposed with respect to one axis unless it is completely machined at one setting or finished all over on centers; but a very close approximation to perfect symmetry can be arrived at by taking special precautions. The operation of turning is not presented as the only faulty one, but as a very fair example. The turner, be he foreman or journeyman, is mainly interested in the maximum quantity of work he can get satisfactorily through the view room. Naturally, therefore, he tends to study his own convenience and to sacrifice aught that tells against rapid production. Experience and tradition will be his guides when engaged on parts, the purpose of which he fully understands (or the inspector fully understands), and lead him to preserve to the best of his ability true relationship between essential features, and to sacrifice, if necessary, those less important. But what is there to indicate a right selection on new and strange pieces whose exact purpose it may be troublesome for him to discover, or possibly beyond his comprehension?

It would be absurd to insist on perfectly true relationship between every part of every piece, because the expense would increase out of proportion to the improvement. But experience proves that it pays to be over-exacting, if anything, even if it involve operations which, on the surface, appear less economical than an alternative series. Left to themselves the shop foremen will generally contrive at last to arrange processes so that a satisfactory result ensues. But at what a cost. And when a critical examination is made of the means they have adopted, it will be found too frequently that they have forsaken economical methods needlessly.

It might be a gain if draughtsmen would recognize the difficulty, and would assist to overcome it by stating which features they required to be perfectly in right relationship, and if they assigned limits to permissible departures from perfection. For example, suppose some small wheels were being turned from bar stock for a purpose which allowed the periphery to be somewhat eccentric with the bore with no evil result. The drawing might stipulate that the eccentricity should never exceed 0.002 inch, say. Unless the inspector were informed by some means of this tolerance, he might reject perfectly satisfactory wheels; on the other hand, he might never dream of testing the relationship, assuming it needless to do so.

Although completed at one setting, many pieces made from the bar are by no means free from irregularities such as that instanced, due very often to an improper choice or application of tools. It is better to recognize the fact and legalize it than to ignore it and lose control. Should it happen that much scrap resulted from the adoption of a tolerance, the right policy would not be recourse to an extra "truing up" operation on another machine, but to careful revision of the tools on the turret lathe. This effect on the methods of machining by the addition of a tolerance in this simple case is worthy of note.

There might be objections to a universal application of this extension to tolerance systems; it might prove complex and unwieldy. But, generally, a short note on a drawing could be made to convey vital information of this character. Unhappily, few draughtsmen could be depended upon to know when it was desirable or what was the most convenient form in which to present it.

Whereas a few years ago a piece would have been completely machined, perhaps, in two operations on an engine lathe, the same piece might now have two or more operations on a semi-automatic turret lathe, another or two on a screw-miller, and be finally ground. Anything from ten to twenty distinct operations may often be found necessary to obtain economical production. On the other hand may be seen splendid manufacturing machines used in a way best described as "poking," and justified by the phrase "Our work is so very fine." There are extremely few cases, however, in which speed and essential accuracy of production cannot be combined, providing the determining factors of each process are designed by one mind—a critical mind cognizant of the fallacy of the popular belief that a system of jigs merely accurate in construction is bound to produce accurate work.

* Reproduced from *Engineering*.

Science in Postage Stamps

Postage stamps do not often afford material for scientific discussion, but an interesting point is mentioned by Mr. Sam S. Buckley in his book on the marginal varieties of the Edwardian stamps of Great Britain (published by Oswald Marsh, London), in connection with a change that was initiated in the autumn of 1911 in the mode of perforating the new English issues. Until then the horizontal and vertical perforations were at the same distance apart, namely 14 in 2 centimeters. It was found, however, that the stamps would not tear well along the horizontal lines, and the explanation was that in machine-made paper the fibers have a tendency to lie in certain directions, thus making the resistance to tearing unequal in different directions. A remarkable result of experiments was the conclusion that resistances could be equalized by using fifteen perforations horizontally to fourteen vertically, the extra perforation making all the difference.—*Nature.*

The Coking of Coal at Low Temperatures*

An Oxygen-Free Atmosphere Essential for the Best Results

By S. W. Parr, Professor of Applied Chemistry, and H. L. Olin, Research Fellow, University of Illinois

I. INTRODUCTION.

Purpose of the Investigation.—The investigations here discussed had two general purposes in view: (1) to discover some fundamental facts pertaining to the properties and characteristics of bituminous coals; (2) to determine the feasibility of modifying the composition of raw coal in order that a different type of fuel might be produced, or possibly an alteration accomplished of the entire fuel content into forms better suited to present-day requirements.

Scope of Previous Investigations.—In earlier experiments[1] (1907 and 1908), the information developed was mainly of the type indicated under the first division; for example, the experiments early indicated the important rôle played by small amounts of oxygen in the gases surrounding the heated masses of coal. The ease with which carbonaceous matter absorbed or united with oxygen was so striking that it seemed desirable to follow the matter into detail regarding the temperatures at which oxidation takes place, and its effect upon the material in hand. As a result, the whole matter of coal oxidation at low temperatures was opened up as one of extreme importance. One fundamental fact brought out in the study[2] was the absorbent power of freshly-mined coal for oxygen, and the part oxygen played in producing certain changes in the coal and promoting the initial form of deterioration in storage. Again[3], the prime element in all the phenomena was seen to be that of oxidation. It will thus be seen that these preliminary studies on low temperature distillation, while mainly bringing into view what might be termed the scientific or fundamental properties of the material, at the same time determined facts which have had much to do with developing the practical application of the information in its relation to storage and spontaneous combustion.

In the second phase of the earlier study, i. e., its industrial side as related to the development of a special type of fuel, it seemed to be established that below a certain temperature, say 700 deg. Fahr., the heavy hydrocarbons, those chiefly responsible for the formation of smoke, could be driven off, yielding a gas of high illuminating power, a tar with high percentage of volatile oil, and a solid which, while it could be burned without smoke, was friable and not well adapted to ordinary use as a fuel.

Outline of Present Investigation.—In the present studies, the friable or non-coking tendency of the earlier product has been found to depend directly upon the amount of oxidation that has occurred both in the preliminary exposure at ordinary temperature and in the process of heating to moderately high temperatures.

The fact that a coke of good texture could be produced when a careful exclusion of oxygen had been effected, has given special interest to the present experiments. In addition, important facts have developed in connection with the study of the various by-products These by-products have also been more or less modified in their characteristics by the exclusion of oxygen

Briefly outlined, the present studies have developed three lines of industrial interest.

First. The possibility of developing a smokeless fuel of good texture and admirably suited to domestic as well as to general industrial use where absence of smoke is essential. The accompanying by-products promise to be of special value. These consist of (a) Ammonia, though smaller in quantity than the yield obtained at higher temperatures; (b) Illuminating gas of high candle-power and high heat value; and (c) Tar, which is composed almost entirely of oils, with a minimum amount of pitch and free carbon. Some of the oils produced are of peculiar structure and may have more than passing interest, two of the fractions, for example, being readily oxidizable. The iodine absorption numbers of the lighter fraction are as high as 165.

Second. They suggest a possible method for the manufacture of producer gas which would be free from present difficulties attending the use of bituminous coal, and would convert a much higher per cent of the fuel into the gaseous form. In view of recent developments in the matter of combustion, efficiencies are possible[4] where gaseous fuel is available which are almost revolutionary in character.

Third. There are opened up interesting possibilities in the production of coke, briquettes or other forms of fuel in a dense and stable form to meet certain requirements of shipping, storing, foundry, and other industrial uses. Certain facts developed in these studies will be found to throw some light on the problem of coking, which is at present but little understood[5].

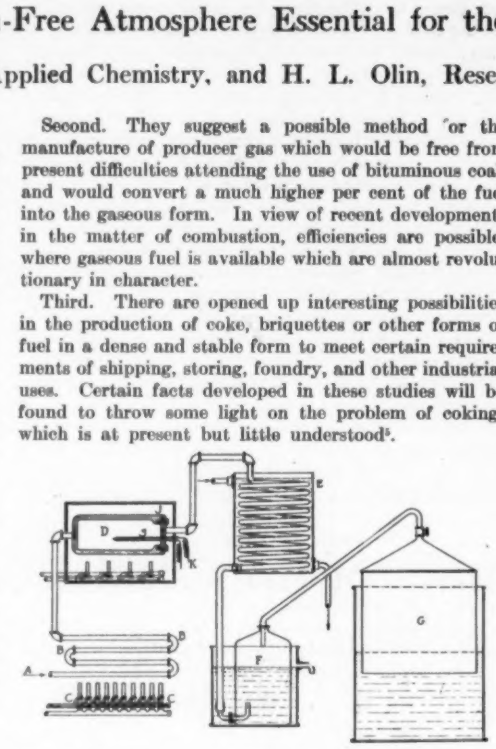


Fig. 1.—Apparatus for Coking Coal in an Atmosphere of Steam.

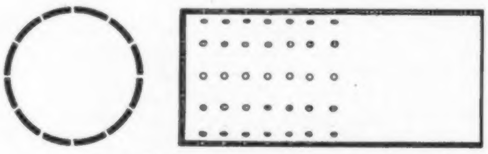


Fig. 2.—Container for the Coal to be Coked.

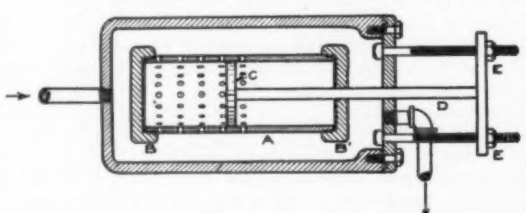


Fig. 3.—Container for Coking Coal Under Pressure.

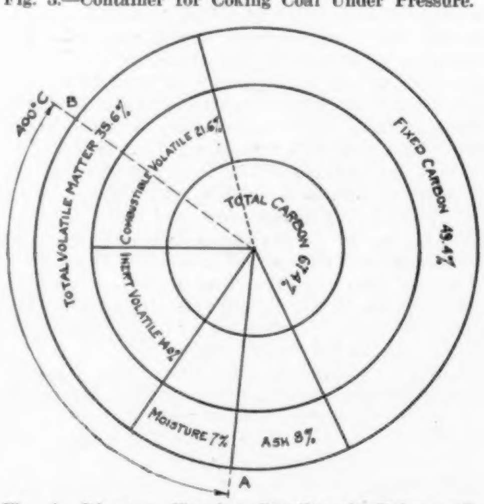


Fig. 4.—Diagram Showing Constituents Driven off Below 400 Deg. Cent.

II.—EXPERIMENTAL WORK.

Apparatus.—The apparatus employed is illustrated in Fig. 1. From the high pressure main at *A*, steam was admitted to *BB*, a 5/8-inch pipe 11 feet long, fitted with two return elbows. The steam was then heated by a 26-burner combustion furnace, *CC*. The retort *D*, 18 by 8 inches, containing the coal, was fitted with a head *J* held in place with set-screws and sealed with asbestos. From the retort, the distillates were conducted by a pipe to a condenser *E* connected in turn with a large wash bottle *F*. Here the oils and tars were collected while the gases passed on to the gasometer *G*. A Hoskins nickel-nichrome thermocouple, inserted through a stuffing box *S* and joined to a millivoltmeter *K* measured the temperature of the retort contents. A battery of burners placed directly under the retort provided a means for securing additional heat, which was retained by means of an asbestos-lined oven which entirely surrounded both the retort and the furnace.

Use of Superheated Steam.—Superheated steam was used in this series of experiments as a medium for carrying the heat into the coal mass, in order to distribute the heat evenly throughout the coal and thus obviate the necessity for revolving the container.

Coal Used.—Table 1 gives the data concerning the coals used. It should be noted that since these studies were made for the purpose of testing the coking powers of the different coals and not to determine their relative commercial values, many of the samples selected were cleaner than the general run-of-mine. The low ash and sulphur percentages result from the exclusion of pyrites.

TABLE I.
COMPOSITION OF COAL.

Mines Counties, Illinois.	Moisture	Ash.	Volatile Matter.	Fixed Carbon.	Sulphur.	B. t. u
Vermilion..	8.80	8.72	43.05	39.43	2.88	12,673
Franklin...	6.84	7.38	37.96	47.82	1.33	12,770
Saline......	3.93	5.80	37.86	52.41	1.54	13,593
Macon.....	8.70	12.12	39.30	40.88	2.30	11,417
Perry......	7.19	10.05	35.42	47.34	.80	12,153
Williamson	5.30	8.55	36.50	49.65	2.77	12,640

Operation.—A quantity of coal sufficient for one run only from 2,500 to 3,000 grammes, was crushed at one time. In the first experiments, the pieces ranged from ¼ inch to buckwheat size, the dust being removed by a sieve. At first the coal was put directly into the retort, but it was found that the circulation of the steam was retarded, delaying the heating of the mass. To remedy this, a cylindrical sheet-iron container, 6 inches in diameter, perforated with small holes, was made to hold the charge. This shell (see Fig. 2) being smaller than the retort and having a surrounding space of about 1 inch, allowed a free distribution of heat. It was used throughout the remaining runs of the series.

Steam was admitted from the main and allowed to blow through the system until the air was entirely displaced. The combustion furnace was next started and then the burners under the retort. The coal was not stirred after heating had begun.

Table 2 exhibits the average working conditions. By improving the facilities for applying external heat to the retort, the time of the later runs was reduced to an average of about five hours.

TABLE II.
TEST CONDITIONS: FIRST SERIES.

Run No.	3	4	5	6	7
Wt. of coal[1], grams.	4800	5351	2195	3498	3398
Wt. of residue, g...	4030	4112	1895	2810	2895
Max. temp. (deg. C)	475°	515°	450°	410°	430°
Ratio of coke......	84%	76.8%	86.3%	80.3%	85.2%

Distribution of Products.—Table 3 illustrates the distribution of products.

TABLE III.
EXPERIMENT[3] NO. 11.

Coal used[2]............................	Electric Mine, Danville, Ill.
Temperature (average)...............	450 deg.
Time of distillation..................	5 hours
Volatile matter in original coal not including moisture..................	43.00
Volatile matter in coke residue.......	27.95
Volatile matter in coke residue referred to original coal...............	22.01
Loss in weight of original coal, volatile matter only, not including moisture	20.28
Total volatile matter derived as above, not including moisture............	42.29
Total material, removed by distillation, including moisture............	29.10

[1] Nineteen runs were made in the first series, using Williamson Company coal for the first 10 tests. In the other tests, the coal came from the following counties in the order given. Vermilion, Williamson, Franklin, Saline, Macon, Vermilion, Vermilion, Williamson, Vermilion.

[2] Selected as a typical example.

[3] For methods of calculating percentages of coal constituents in this and succeeding tables see Bulletin No. 16, p. 209, Ill. Geol. Sur.

* Extracts from Bulletin No. 60 of the Engineering Experiment Station of the University of Illinois.

[1] The present investigations are a continuation of the work carried on in 1907-8 and presented as a preliminary report under the title of "The Modification of Illinois Coal by Low Temperature Distillation," Bulletin No. 24, University of Illinois, Engineering Experiment Station, by S. W. Parr and C. K. Francis. 1908.

[2] "The Occluded Gases in Coal," Bulletin No. 32, University of Illinois, Engineering Experiment Station, by S. W. Parr and Perry Barker.

[3] "The Weathering of Coal," Bulletin No. 38, University of Illinois, Engineering Experiment Station, by S. W. Parr and W. F. Wheeler; also "The Spontaneous Combustion of Coal," Bulletin No. 46, University of Illinois, Engineering Experiment Station, by S. W. Parr and F. W. Kressmann.

[4] Surface Combustion. Proc. Am. Gas Inst., 1911. By Prof. W. A. Bone. In this article Prof. Bone gives data showing an efficiency in the generation of steam by use of the principle of surface combustion of 94.2 per cent. It should be noted, however, that this efficiency is based upon the net heating value of gas.

[5] "The question as to what really is the factor that produces the coking tendency characteristic of some coals has been a matter of some speculation among manufacturers and users of coke for two hundred years and we are no nearer to its solution now than were the investigators of two centuries ago."—*Iron Age*, 1907. F. C. Keighley.

TABLE IV.

YIELD OF PRODUCTS FOR DIFFERENT PERIODS OF HEATING.

Time of Heating.	3 hours.	6 hours.
Coal	3,000 grammes	4,000 grammes
Coke	2,327 grammes	2,902 grammes
Per cent coke	77.50%	72.50%
Weight of tar	238.5 grammes	316.0 grammes
Per cent tar	7.93%	7.90%
Weight of total water	208.5 grammes	348.4 grammes
Per cent free moisture	3.38% or 6.93%	3.00% or 8.71%
Per cent water constitution	3.55%	5.71%
Volume of gas at 760 millimeters and 0 degrees	87 liters	134.7 liters
Calculated to cubic feet per pound of coal	0.46 cubic feet	0.54 cubic feet

From the preceding tables a fair indication is given of the ratio of distribution of the main products of decomposition. A study of these three products, gas, tar and coke, has been made, sufficient to determine their general characteristics and value.

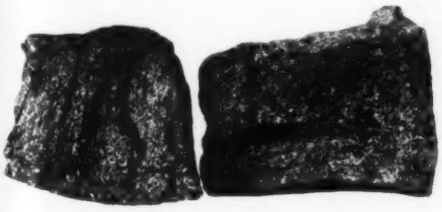


Exhibit 2.

Exhibit 1.

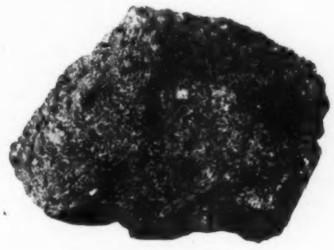


Exhibit 3.

Exhibit 4.

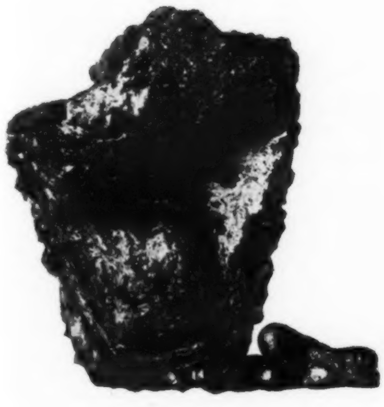


Exhibit 5.

Exhibit 6.

Exhibit 7.

Exhibit 8.

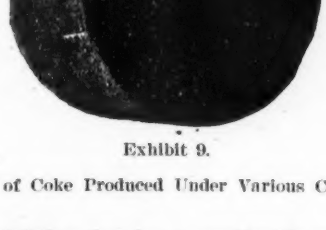


Exhibit 9.

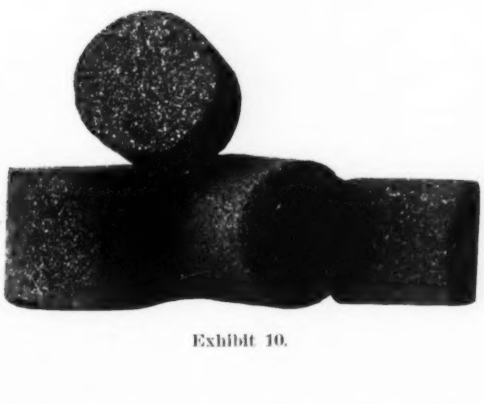


Exhibit 10.

Samples of Coke Produced Under Various Conditions.

III.—GASES.

Analysis of the Gas.—For details of the methods employed in these analyses the reader must be referred to the original bulletin. Table 5 shows the average of results obtained under satisfactory conditions, from gas evolved at an average temperature of 400 degrees.

TABLE V.

GAS FROM DANVILLE ELECTRIC MINE COAL.

H_2S	CO_2	Illuminants	CO	H_2	C_2H_6	CH_4	N_2	B. t. u.
3.2	5.7	8.3	5.2	5.0	14.4	51.4	5.7	1,032

The computed heat value of this gas was 1,024 B. t. u. and agrees closely with that determined directly. Heat values of the different gases as given by Abady[6] were used as the basis of calculation.[7]

[6] Gas Analyst's Manual, p. 521, 1902.

[7] According to J. H. Coste (*Chemical Engineer*, February, 1911) it has been found from Julius Thomsen's figures that the average calorific value of the unsaturated hydrocarbons is equivalent to that of propylene, C_3H_6.

Heat Value.—It will be noted that this gas is relatively of high heating value, 1,024 B. t. u. per cubic foot. Compared with ordinary city gas at 600 B. t. u. per cubic foot, this gas has a heat value about 70 per cent greater, i. e., 1 cubic foot at 1,024 B. t. u. would be equal to nearly 1.7 cubic feet at 600 B. t. u.

Sulphuretted Hydrogen.—The gas is practically free from naphthalene but has a considerable content of H_2S. The latter feature is unexpected, since the temperature of decomposition of FeS_2 is 1,000 deg. Cent. and above. Doubtless, therefore, the sulphuretted hydrogen present is in the main due to the breaking down of the organic sulphur. It seems to be entirely in the form of H_2S and, therefore, easily removable by the usual methods of purification.

Ammonia.—Any by-product process for the carbonization of coal would, of course, take account of the nitrogen liberated in the form of NH_3. At the temperature employed in these experiments, it would not be expected that any considerable part of the nitrogen organically present would be decomposed. The following values are shown in a distillation[8] varying in temperature from 375 to 400 deg. Cent. In this work the entire distillate from a run of 3,000 grammes was retained and the total ammonia of the liquor determined. It was found to contain ammonia as NH_3 sufficient to represent a yield of 0.8 pound per ton of coal, somewhat less than one quarter of the yield from high temperature distillation. It is not certain that the value of this product would pay for its recovery.

[8] Experiments by Mr. E. C. Hull, Fellow in Chemistry, University of Illinois, Engineering Experiment Station, March, 1909.

Summary of Data Concerning the Gaseous Product.—Distillation of Illinois coals at temperatures averaging 450 deg. Cent. and not exceeding 500 deg. Cent. produces a gas having a heating value exceeding 1,000 B. t. u. per cubic foot. The yield approximates ½ cubic foot per pound of coal which, at the heat value present, would represent a yield of 1.00 cubic foot per pound of a gas with a heat value of 500 B. t. u. per cubic foot. The ammonia yield is low, being approximately 3 pounds of ammonium sulphate per ton of coal. Decomposition at this temperature extends to the oxygen compounds, which are in the main carried off and appear in the condensate instead of in the gaseous product.

IV.—TAR.

Composition.—The amount of tar recovered from the distillations approximates one half of the yield of volatile matter and in the sample noted where a direct weighing was made (Table 4), this material represents very nearly 8 per cent by weight of the original coal. An exhaustive study of this material would be an elaborate topic for research in itself. We can, therefore, give only the general characteristics of the material as found by fractional distillation as follows:

TABLE VI.

FRACTIONS FROM LOW TEMPERATURE TAR.

	grammes	
Amount of tar (exclusive of water carried over)	375.0	
Light oil (20 to 100 degrees)	39.1	10.5%
Fraction (b) (100 to 200 degrees)	109.1	29.1
Fraction (c) (200 to 240 degrees)	111.8	29.8
Fraction (d) (240 to 275 degrees)	20.6	5.5
Coke residue	80.0	21.3

From the results as given in Table 6, it will be seen that 75 per cent of the material classed as tar is in reality oils of different specific gravities and thus of much greater value than the pitch proper. This latter product, moreover, is much smaller in amount than is produced with high temperature distillation. In the latter case over one half of the tar is pitch, with a considerable content

of free carbon suspended in the material. The low temperature product is approximately one fifth a pitch residue with some suspended carbon present, seemingly depending on the extent to which the temperature of the coal mass has been carried above 400 degrees.

Properties of Oils.—The further examination of the oils distilled from the tar has developed the interesting fact that these oils are readily oxidizable. Further study of the oils recovered is necessary in order to determine their specific values. Their ready oxidizability opens up a very interesting and suggestive field. For example, this feature is a marked characteristic of drying oils, turpentines, etc., used in paint mixtures. At any rate, it may be said of the oils which make up the element of the tar, they are available directly as fuel or for enriching or carburetting water gas. For example, if the process were continued to include the manufacture of water gas from the coke residue, the oil of the tar would doubtless enter into the reaction in the same manner as the crude petroleum now used, and thus would furnish the needed enrichment without the clogging effect which results when the attempt is made to use the raw coal directly in the manufacture of water gas.

V.—COKE.

Yield of Coke.—The yield of coke, under average conditions, as already noted in previous tables, is approximately 75 per cent to 80 per cent. This factor will, of course, vary greatly with the amount of ash originally in the coal and with the temperature at which the distillation has been carried on. These items of variation are shown in the following table where material of widely varying composition was used.

TABLE VII.

COMPOSITION OF COKE RESIDUES.

	Experiment No. 11 Vermilion County.	Experiment No. 13 Franklin County.	Experiment No. 14 Saline County.
Moisture	0.34	0.40	0.28
Ash	11.15	9.28	6.97
Volatile matter	27.61	26.60	23.50
Fixed carbon	59.90	63.72	69.23
Sulphur	2.58	1.21	1.20
B. t. u.	12,892.00	13,446.00	13.746.00

TABLE VIII.

SHOWING THE YIELD OF COKE FROM VARIOUS COALS REFERRED TO ORIGINAL COAL—DRY BASIS.

	Experiment No. 11.	Experiment No. 13.	Experiment No. 14.
Ash	9.56	7.92	6.04
Volatilematterexpelled	25.48	18.00	19.12
Residual coke	78.10	84.72	84.86

Oxygen Remo ed.—The decompositions occurring at temperature in the neighborhood of 400 deg. Cent. include the liberation of oxygen, or, as it is frequently designated, the water of constitution. Since this ingredient of the raw coal is non-combustible[9], it has the same function as so much ash. Its removal, therefore, serves to make of the resulting material a richer or more concentrated fuel. This feature is still further promoted by the removal of the hygroscopic or free moisture which usually exceeds in amount the water of composition. This point may be illustrated by the accompanying table wherein the heat values per pound of the original coal are compared with the heat values per pound of the residual coke. There is also given an estimate of the amount of non-combustible material removed in the form of water in the process of decomposition.

TABLE IX.

Samples.	B. t. u. per lb. as Received	B. t. u. after treatment per lb.	Gain thermal units.	Gain per cent.	Estimated Loss of total Non-combustible free and combined moisture.
Williamson Co.	12,695	13,150	455	3.60	10.30
Saline Co.	13,583	13,746	163	1.63	8.93
Vermilion Co.	12,673	12,892	219	1.72	13.30

Properties, Porosity, Hardness, etc.—The coke material obtained by this process varies in character somewhat with the kind of coal used, and also the amount of pressure employed during the carbonization. The Williamson County coal, for example, gives a coke of much finer texture and less porosity than the coal from Vermilion County. With a view to determining the reason for this greater porosity or to finding the conditions that would modify it, the attempt was made to carry on a test with the coal sample under pressure. To this end the following apparatus was used:

Apparatus.—*A*, Fig. 3, is an iron cylinder, 8 inches by 4 inches, fitted with screw caps *B* and *B'*, which received the coal. The movable piston *C* to which is attached a long rod *D*, is pressed against the charge by tightening the nuts *EE*. The cylinder is perforated with small holes to allow the escape of gases. This contrivance was fitted into the retort originally used and heat was applied as before.

[9] Bulletin No. 3, Illinois Geological Survey, p. 32-33.

Exhibit 1 shows the results obtained when pressure is applied slowly during the entire heating period. The outer portions passing through the temporary state of fusion soon harden and form a wall which resists external pressure. The inner core, therefore, is extremely porous. When sufficient pressure is applied, the outer part fractures and, as in this case, the residue comes out broken up into small pieces. The coke shown in the figure is from coal from Perry County. The specific gravity of the outer portions of the mass is 0.733 against 0.652 when coked without pressure.

It was evident, therefore, that in order to get a firm block, pressure must be constant. In the next run, the charge was rammed into the cylinder and the piston was screwed up tightly but not moved after heating had begun. The resulting column cohered well and showed the same increase in specific gravity as the one mentioned above.

Illustrations of Various Porducts.—An interesting feature of the product is the complete fusion of the mass, where proper conditions exist, i. e., the individual particles of coal of buckwheat or pea size have completely lost their identity, the resulting homogeneous mass showing no lines of demarcation from the original pieces of coal. The texture, however, in some cases is finer or closer than in others. These points are well illustrated in photographs of typical masses as reproduced in exhibits 2 and 3, for coals from Southern Illinois. Exhibit 4 represents a somewhat coarser texture. It was made from Vermilion County coal. For the composition of these samples, reference is made to Table 7. [Exhibits 1 to 4 are here referred to.] Exhibit 2 from Saline County coal showed a crushing strength of 750 pounds per square inch[10]; exhibit 3 from a Franklin County sample crushed at 900 pounds. On account of its coarse cellular structure, exhibit 4 showed little rigidity, and broke down at a pressure of 300 pounds.

Resume Relating to the Coke Product.—It is evident upon examination of the coke product obtained, as above described, that we have here a fuel of firm texture, not readily broken down by handling and producible in the most convenient sizes for handling and for efficiency in combustion. It is, moreover, in a more concentrated form, in that for the most part, the free moisture and the water of constitution have both been removed. Thus, in freshly mined coal there would be eliminated from 15 to 20 per cent of inactive material. Again, the heavy hydrocarbons have been removed. These are the constituents most directly responsible for the formation of smoke in the combustion of untreated coal. It is to be noted further that because this coke has been subjected to a temperature just approaching a red heat, it will not begin to evolve volatile matter, when thrown upon the fire, before it again comes up to or passes that temperature.

The effect of this point is twofold; first, there is obviated the cooling effect which must be necessary in the vaporization of moisture in the raw coal which also lowers the temperature just when a high temperature is needed for burning the heavy hydrocarbons; and second, the remaining gases to be evolved consist almost wholly of ethane or marsh gas (CH_4) and hydrogen, both of which are readily combustible. The hydrogen, of course, burns with a non-luminous flame and is incapable of making smoke. The marsh gas (CH_4), though it has carbon in its composition, adds but little luminosity to the flame and is almost incapable of producing smoke in the process of combustion.

It may be well to analyze briefly the processes of combustion as they occur in an ordinary hand-fired furnace. The first result of throwing a mass of coal upon a fire is to lower the temperature during the time of volatilization of the moisture in the coal. Theoretically, the temperature of the mass during this process would remain at or slightly below 100 deg. Cent.

Other factors tending to lower the temperature would be the specific heat[11] of the coal and the heat necessary to effect the decomposition, since it is probable that the decomposition reactions are endothermic up to approximately 300 deg. Cent.[12]

It is to be noted that during this depression of the general temperature there are being distilled from the coal such volatile substances as are liberated at these lower temperatures. This point can best be illustrated by means of the accompanying diagram. In Fig. 4, the region between the lines *A* and *B* may be assumed to include those volatile constituents that are driven off at a temperature below 400 deg. Cent. This area includes the free moisture of the coal, the combined moisture or water of constitution, or as some prefer,

[10] John Fulton (Coke, p. 334) gives 1.200 lb. per sq. in. as the ultimate crushing strength of standard Connellsville coke; by-product coke is, in general, considerable stronger. The crushing strength is important in reference to the load or burden the coke can withstand in the furnace without crushing.

[11] Bulletin No. 46, University of Illinois Engineering Experiment Station, Parr and Kressman, p. 34.

[12] Bulletin No. 24, University of Illinois, Engineering Experiment Station, Parr and Francis, pp. 46-47.

the oxygen compounds of the coal, shown on the chart as inert volatile; and, in addition, some of the pure hydrocarbons which constitute a portion of the true volatile combustible matter. It is, moreover, the nature of this latter or volatile combustible material with which we are just now concerned in this discussion of the processes of combustion. It is to be noted first that this volatile matter contains the bulk of the heavy hydrocarbons. By this is meant that they belong to the higher series of any of the homologous compounds present which in general are characterized by a higher percentage of carbon. For example, if the series is that of marsh gas or methane CH_4, i. e., $C_n H_{2n+2}$, then the next higher order of this series would be ethane or C_2H_6, and the next, propane or C_3H_8. The carbon percentages, respectively, being 75, 80, 81.8, etc. Again, a very considerable part of the volatile matter delivered at this temperature belongs to the methylene series $C_n H_{2n}$, and the first known member of the series is ethylene or olefiant gas, C_2H_4, with a carbon percentage of 92.92. Moreover, this ast compound may be made to break down under higher heat into members of other series, as acetylene, C_2H_2, benzene, C_6H_6, and naphthalene, $C_{10}H_8$. Other members of the ethylene or paraffin series are found which ally the resulting complex mixture quite closely to the very complicated compounds with which we are familiar in petroleum.

The point to be noted in this phase of the discussion is the fact that these compounds discharged at this relatively low temperature, and having these high percentages of carbon, are the most difficult of complete combustion without the formation of smoke.

It is not necessary here to discuss the mechanics of conbustion of hydrocarbons. As a result of the researches of H. B. Dixon[13] and of Prof. Bone[14] the selective theory of oxygen for hydrogen or the dogma of "preferential combustion of hydrogen" has been obliged to give place to the theory of the intermediate formation of "oxygenated" or "hydroxylated" molecules. In any event, or whatever the theory finally developed by Prof. Bone in his most important researches on combustion, the fact remains that these heavier hydrocarbons are the most difficult of all with which to effect complete combustion, and that even under favorable circumstances the tendency in their combustion is to form condensation products in which free carbon largely predominates. The faulty reaction is thereby made visible to the eye as smoke. A good illustration of this fact is found in acetylene gas, which requires a special burner with special provision for an extra oxygen supply in order to produce a smokeless flame.

Smokeless combustion of raw coal is secured, therefore, by observing the principles indicated above; i. e., there must be uniform and gradual accession of fresh coal and a combustion chamber maintained at a sufficiently high temperature, and the same extending over a sufficient space to permit of ultimate mixing and contact of the oxygen with the combustible gases. Other conditions such as accelerating the reaction by introducing the principle of surface combustion, as developed by Prof. Bone, may at some time be added to the mechanical and physical conditions now in vogue. But while these provisions are readily adapted to large steam generating units, they are impossible of application to the larger members of combustion processes such as are common to the small plant, house heaters, and possibly to locomotives. It is these latter cases especially that demand a modified fuel which can be burned without the formation of smoke.

It will thus be seen that in the low temperature distillation of coal, processes have been put into operation which have taken out the heavy smoke-producing ingredients, and have also removed the moisture, both free and combined, which are chiefly responsible for the depression of temperatures under ordinary conditions. There is left, moreover, as volatile matter, practically these volatile substances only; methane CH_4 and hydrogen, which most easily of all the gaseous products from coal, maintain a smokeless combustion.

VI.—THE FORMATION OF COKE.

The experiments as thus far conducted seem to throw some light upon the matter of coke formation. In this discussion of the theories involved, it may be helpful to formulate certain hypothetical conditions which have had more or less confirmation in these studies, as follows:

First. For the formation of coke there must be present certain bodies which have a rather definite melting point.

Second. The temperature at which decomposition takes place must be above the melting point.

Third. Where the compounds that satisfy the first and second conditions are unsaturated, it is possible by subjecting them to oxidation to so lower the temperature of decomposition as to alter the second condition prescribed, in which case coking will not occur.

Discussion of Conditions.—The first condition prescribed above may be well illustrated by the behavior

[13] Phil. Trans. 1893, 159; Trans. Chem. Soc. 61, 873 (1892).

[14] *Chem. News*, 102, 309 (1911).

of sucrose or cane sugar. This substance has a rather low melting point, say, 160 deg. Cent. This melting point, however, is just below the temperature of decomposition. Where this point is reached, gaseous products in the form of steam, etc., are delivered, leaving behind, if the high temperature is continued, a mass of coke. On the other hand, if starch is heated in a similar manner, it does not melt but its first action is that of decomposition. When this is carried to completion, there remains not a strongly coherent mass but easily disintegrated particles of carbon. Pure cellulose behaves in a still more striking manner, showing no fusion properties whatever as may be demonstrated by distilling in a closed tube some cotton fiber, or other form of cellulose such as filter paper beaten to a pulp and dried. Wood, however, if not disintegrated, as in the form of sawdust, has enough resinous material closely associated with the fibrous structure to bind the carbon filaments resulting from the decomposition of the cellulose by reason of the fact that these gums, or resins, have a melting point below that of their decomposition temperatures, and thus form a binding film of carbon throughout the mass, producing a sort of coking effect which we find in charcoal.

In the case of Illinois coals, we find the first prerequisite formulated above present in a marked degree. As an illustration of the fact of a low melting point, reference is made to exhibit 5, which is a photograph of a mass of such material, which exuded from a sample of Vermilion County coal, subjected to the usual treatment as described on page 252. The lump shown is a part of a mass that flowed out of the container, forming a bubble-like puddle. It would seem, therefore, that this type of coal from the north Danville field (Electric mine) has the first essential for coke formation in a marked degree.

As illustrating the conditions which exist where oxidation had been allowed to take place, an example is given in exhibit 6. This was made from a weathered sample of coal from Niantic. It had little if any tendency to fuse; the individual particles of coal still retain their form and the mass may be easily crumbled between the fingers. It should be noted that this result is not due to any inherent quality possessed by the original coal; a Danville mine sample, for instance, weathered to a like degree, gives the same results.

Test No. 9.—Another verification of this point, though in a more marked manner, was the result of test No. 9. The coal used was the fine material which had collected from the preparation of the previous tests, all of which had given excellent samples of coke in their freshly prepared condition. A quantity of coal passing through a 10-mesh sieve had accumulated through a period of about six weeks and had been stored in an ordinary coal hod in the grinding room. After being heated for eleven hours under conditions identical with those of the preceding runs, it showed no signs of fusion and was entirely without coking properties.

It is evident from these tests that the very great avidity of fresh coal for oxygen is evidence of the presence of those compounds which satisfy the first of the hypothetical conditions given above and the subjection of the coal to oxidation destroys the fusion property of the fresh coal and produces a condition corresponding to that described under the third proposition, in which the coking property is lost.

Other studies on the nature of the coking process were carried out as follows: The apparent plasticity exhibited by the coal during certain stages of the treatment suggested the idea of compressing it into a briquette at the time when it would most easily yield to pressure and when it would presumably cohere without requiring an artificial binder. Accordingly, a cupel press with a pressure of 500 pounds was provided and the retort was charged with Danville mine coal. At the time of maximum evolution of gas, the heat was suddenly shut off and the retort quickly opened. It was found at this point that the outer and hotter portion of the mass was hard and unyielding. A soft inner core was discovered, however, and portions of this were put into the press. The resulting briquette is shown in exhibit 8. The escaping gases have swollen it considerably. Determinations of the amount of volatile matter possessed by the coal when in the plastic condition showed that this constituent had been reduced very little, from 38 per cent to 30 per cent. In short, the state of fusion seems to exist in early stages of distillation but disappears before the process has proceeded far.

In one of the earlier tests with Danville mine coal, using the apparatus described in Fig. 3, the extreme fusibility of this type was again demonstrated. As the piston was slowly forced in, pencils of bituminous matter were squeezed out through the holes of the cylinder. Exhibit 5 includes some of these nodules. The fact that there was a selective separation of bitumen is proved by a comparison of the ash values, the residue as a whole having 13 per cent, the nodules 8 per cent of ash.

The readiness with which the cementing material ran to waste seemed to indicate that the coal contained a superfluous amount of it, more than was necessary for binding itself together. The correctness of this view was shown by a series of runs in which crushed gas house coke and anthracite were heated with varying amounts of bituminous coal.

Exhibit 7 shows the hard firm product resulting from the mixture of equal parts of Majestic bituminous coal and gas house coke, both crushed to 20 mesh. Fairly good results were obtained in the next run with 75 per cent of the coke and only 25 per cent of Danville Electric coal. In like manner, powdered anthracite and bituminous coal in ratios varying from 1 : 1 to 3 : 1 were firmly cemented together. Pitchy material no longer exuded from the retort, being absorbed, seemingly, by the added substance.

One of the essential factors in this scheme for briquetting loose infusible material with bituminous coal is the use of the press for keeping the two substances in close contact. On account of the difficulty of applying such a contrivance in industrial work, attempts were made to attain the desired end by using temporary binders, i. e., substances which might hold the particles together closely until the permanent coal binder could relieve them.

Mixtures of Danville mine coal and Danville mine coke residue No. 17 in the proportion 3 : 1 were thoroughly moistened with water and pressed (1) in the cupel machine and (2) in a testing machine up to 1,000 pounds per square inch. Neither of the briquettes survived the subsequent heating, being disintegrated, seemingly, by the escaping steam. The same effect, though to a much less degree, was noted when coal tar was employed. The resulting briquette retained its shape, but was rather soft and friable. Crude molasses, of all the binding materials tried, proved to be the best for this purpose. Different percentages of the molasses, ranging from 5 to 15, were tested out at different times. Below 10 per cent the strength of the briquette was much diminished. Exhibit 9 is a 3 : 1 mixture of Danville mine coke residue and fresh Danville mine coal, both ground to 20 mesh, first bound with 11 per cent of molasses and then pressed in the cupel machine. The cake was next heated in the retort under the atmospheric conditions of all the preceding runs. This briquette, 2 inches high and 2 inches in diameter, has a crushing strength of 550 pounds per square inch. Exhibit 10 shows anthracite briquettes made in the same way. They have a specific gravity of 1.02 and crush at 650 pounds per square inch.

These tests seem to show that the fusible substance of Illinois coals is the true binding material in the coking process; that it is present in such abundance as to produce a coke of too open and spongy a character as a result of the evolution of the large amount of gaseous products which result from its decomposition. In this respect, it is paralleled by the behavior of sugar in the process of coking, which yields as a result of the large volume of escaping gases a very porous mass of sugar-coke or carbon. However, if the raw coal is mixed with a considerable amount of material which has already gone through the coking process, or which has at least given off the larger part of its gases, and then has been reduced to a fine division like breeze, the cementing material of the fresh coal is able to disseminate throughout the mass, and the gases may also escape without blowing it into a spongy mass, with the result that a coke of good texture is formed. Exactly in a similar way, if molasses or other sucrose or glucose material be substituted for the fresh coal, we shall have again the formation of a dense coke capable of retaining its shape under conditions of firing much better than where a plastic binder is used. In both cases a strongly cohering mass is produced which meets the requirements of handling, storage, and combustion with the greatest efficiency and the least formation of smoke. A small admixture of raw coal may thus be made to serve the purpose of a binder for material otherwise wasted as coke breeze at a cost which would enable it to compete with the pitch binders now in use. It also suggests a process of fractional coking, or coking in two stages. The first result at the lower temperature furnishes a product which, when ground to a moderate degree of fineness and mixed with a small portion of fresh raw coal, would furnish the essential conditions for producing a coke of dense nature with a binder so distributed as to give the material a strength quite comparable with that produced by coals of the regular coking variety. Moreover, an advantage would be evident in such material, especially for use in household appliances, in that it would be more lively in combustion and less difficult of manipulation in the matter of maintaining a fire than coke made by the usual methods.

One point further is to be noted in this connection. It was said at the beginning of the discussion that superheated steam was employed for the purpose of conveying heat into the material so that it would not be necessary to revolve the apparatus in order to secure an even distribution of heat. It is seen from the above detail of the essential conditions to be observed in the coking of coals, at least of this class, that an atmosphere free from oxygen is of prime importance. Indeed, following the indicated requirement, the coal should be fresh, or as recently mined as possible, and in any event retained in larger sizes than in a broken down or a fine state of division, in order that the least possible opportunity be given for the absorption of oxygen. Furthermore, by first admitting steam or bringing the coal into an atmosphere of superheated steam, the effect is to drive out such oxygen as has been occluded or absorbed by the coal and as yet not chemically combined. This is also brought about at temperatures and other conditions least conducive to a reaction between oxygen and the coal substance. Moreover, from former experiments,[15] it has been shown that no reaction at these temperatures takes place between the steam itself and the coal. These principles have an important bearing on certain recent tendencies to concentrate gas production and coke manufacture in large units and distribute the gaseous products at high pressure. From the above, it would seem that the nearer such units were located to the mine or pit-mouth, the better. If it is found, as seems probable, that the coke residue is a suitable material for further continuation of the gas-making process for the manufacture of producer gas, then the above advantages and essential conditions would be magnified.

SUMMARY AND CONCLUSIONS.

1. Coals of the Illinois type can be coked at a temperature approximately 400 or 450 deg. Cent.

2. The gaseous products consist chiefly of illuminants of high candle-power, and represent, together with the condensible material under (3) following, the chief elements involved in formation of smoke in the ordinary combustion of raw coal. The nitrogen of the coal is liberated as NH_3, at these temperatures, in amounts representing approximately 20 per cent of the total nitrogen present.

3. The condensible distillate consists largely of oils with the minimum amount of tar and free carbon. The oils represent positive values for fuel, for carbureting water gas, or for other specific uses on account of their chemical characteristics as unsaturated compounds.

4. The coke residue has special characteristics which seem to make it of value as a concentrated fuel, capable of combustion without the formation of smoke, suitable for storing without the possibility of spontaneous combustion, and presumably adapted to the manufacture of gas for use in the suction gas producer.

5. Certain facts seem to have been developed concerning the principles involved in the formation of coke which may open the way to the production of a kind of coke of such texture and strength as to make it acceptable for uses that are not now possible with coke made from similar coal, but formed under ordinary conditions, such as are found in the ordinary gas-house retort practice, or that of the by-product coke-oven.

Fresh Light on the Cause of Cancer

By E. F. Bashford

Prof. Johannes Fibiger of Copenhagen describes in a long article in the *Berliner klinische Wochenschrift* for February 17th some experiments which carry our knowledge of the relation between the origin of cancer and external causes a step further. The present writer has been aware of these observations since August, 1911, but they have been in progress since 1907. They have, therefore, been pursued for some five years, which indicates alike the difficulties overcome and the praiseworthy pertinacity of the investigator.

When examining growths found in the stomachs of three wild rats, Fibiger was struck by the presence of nematodes (round worms), and he set himself to determine if they stood in causal relationship to the growths or were accidental concomitants. Cancer of the stomach in mice was described by Murray in 1908 from the laboratory of the Imperial Cancer Research Fund, but at an examination undertaken in consequence of a letter from Fibiger, neither he nor we were able to show the presence of nematodes. The growths occurred in rats obtained from some sources and not from others, and their occurrence coincided with the presence of *Periplaneta americana*. From other sources he was aware of the cockroach serving as a host for round worms. The cockroaches harbored a nematode, and he studied its life-cycle. It lives in the pavement epithelium of the upper portion of the rat's alimentary canal, where it reaches sexual maturity. The eggs containing embryos are passed with the fæces, and on being consumed by the cockroach (either *P. americana* or *P. orientalis*) the embryos are liberated, and wander into the striped muscles of the prothorax and limbs. In these situations they are found after six weeks coiled up trichina-like.

[15] Parr and Francis, p. 45, Bulletin No. 24, Engineering Experiment Station.

When rats eat infected cockroaches, the larvæ are freed and wander into the squamous epithelial covering of the fundus of the stomach, and occasionally also into the gullet, tongue, and mouth. They do not invade the epithelium covering the rest of the canal. Fifty-seven tame rats were fed on *P. americana* infected with the Spiroptera; in fifty-four the nematode was found in the stomach, in seven the growths which had initiated the investigation were found, and in twenty-nine others there were found, the earlier stages of such growths. Feeding rats with eggs containing embryos did not convey the infection. Microscopical investigation showed in the case of seven rats growths resembling the tumor originally observed, together with the certain presence of secondary deposits in other organs in the case of two and possibly of three rats. The structure of the growths was in four out of the seven definitely that of a malignant new growth.

It would appear, therefore, that for the first time malignant new growths have been deliberately produced by experiment through the agency of a living parasite. Fibiger draws the conclusion that the disease is dependent on the presence of the Spiroptera, and, on analogy with other Helminthes, assumes they act by some poison secreted, although he is not prepared to dismiss altogether the possibility of a virus or ultra-microscopical organism being concerned. All the histological pictures found form a continuous series, but they afford no clue to the mechanism of genesis. Important is the observation that the worms were only associated with the primary growths, and were absent from the secondary deposits, showing that the cells had acquired independent powers of growth.

The association of round and other worms with cancerous growths has long been known. Borrel and Haaland described this association for mice from the Institut Pasteur in 1905 for certain growths of the lung and lymph glands. The association of a tape-worm with cancer of the small intestine in mice was described by Bashford and Murray in 1905. Haaland, when working in the laboratory of the Imperial Cancer Research Fund, published an elaborate communication on the association of a nematode with cancer of the mamma in that animal. He assumed its excretions were the cause of chronic inflammation on which nodular hypertrophy, adenoma, and carcinoma developed. Its life-history—notwithstanding continued attempts made in the hope of being able to attack the problem of casual relationship directly—has not been followed to this day, but it was shown to be different from another nematode occurring in the alimentary canal, both nematodes having been identified by Mr. Shipley and Dr. Leiper. And since then there have been many other references in the literature.

The presence of the worms must not be interpreted in the sense that they are *the* cause of cancer, as has been done in the lay Press. They probably act as chronic irritants, of which a legion is associated with the development of cancer. They may be animate or inanimate, e. g., mere direct *physical* injury as in fracture of bone or in the "horn core" of cattle in India, *chemical* as in paraffin, petroleum, tar, arsenic, and aniline cancer, *actinic* as in the case of the short hot clay-pipe, the Kangri, the X-ray, or brand cancers (of cattle). Squamous-celled carcinoma develops in engine-drivers over the shin where the skin has been exposed for years to the direct action of heat. They may be of an infective nature as in Bilharzia for the bladder, the tubercle bacillus where epithelioma develops in an old lupus scar, or *Treponema pallidum*, as in the association of keratosis linguæ with epithelioma of the tongue. The irritant may be a larger parasite, such as worms.

Borrel has suggested that the latter are the carriers of a specific cancer virus; on the other hand, it has been suggested that the relation for all these irritants is a mediate one in quite a different sense, and that the common factor lies in the capacity of the living cell itself to undergo variations in structure and in powers of growth such as have been demonstrated in propagated tumors when subjected to the repeated irritation produced by transplantation, as described in the reports of the Imperial Cancer Research Fund. It is unfortunate that the growths produced experimentally by Fibiger present just as much difficulty in the elucidation of the exact process as do all other natural growths.

In the past the attempt has often been made to produce cancer by subjecting animals to the irritations associated with cancer in man, but without success except possibly in the case of X-rays. As the writer has pointed out, the irritants vary from one mammal to another, and the knowledge of the irritants to which different species and even their individual organs are liable is of very considerable importance, and will require extensive study. Prof. Fibiger is to be congratulated not only in having isolated such an apparent specific irritant, but also, by carefully imitating the natural process, on having produced cancer experimentally through the mediate intervention of a parasite for the first time.

The Population of New York State*

The composition and characteristics of the population of New York, as reported at the thirteenth decennial census, are given in an advance bulletin soon to be issued by the Bureau of Census, Department of Commerce and Labor. Of the total population of New York, 3,230,325, or 35.4 per cent, are native whites of native parentage; 3,007,248, or 33 per cent, are native whites of foreign or mixed parentage; 2,729,272, or 29.9 per cent, are foreign-born whites; and 134,191, or 1.5 per cent, are negroes. The corresponding percentages in 1900 were 39.2, 33.2, 26 and 1.4, respectively, the proportion of foreign-born whites having increased during the decade. In 35 of the 61 counties the percentage of foreign-born whites is less than 15; in 18 it is between 15 and 25; in 6 it is between 25 and 35, and in 2, New York and Kings, it is 35 or over. Of the 2,762,522 inhabitants of New York County, 45.4 per cent are foreign-born whites and only 15.8 per cent are native whites of native parentage. In 23 counties the percentage of native whites of foreign or mixed parentage exceeds 25, being 42.6 in Queens, 41.5 in Erie, and 40.6 in Kings. Of the urban population, 27.2 per cent are native whites of native parentage; of the rural, 66.1 per cent. The corresponding proportions for native whites of foreign or mixed parentage are 36.5 and 19.9 per cent, respectively. The percentage of foreign-born whites is 34.5 in the urban population and 12.8 in the rural.

In the total population of the State there are 4,584,-597 males and 4,529,017 females, or 101.2 males to 100 females. In 1900 the ratio was 98.9 to 100. Among native whites the ratio is 97.5 to 100, and among foreign-born whites 110.5 to 100.

Of the total native population—that is, population born in the United States—88.7 per cent were born in New York and 11.3 per cent outside the State; of the native white population, 10.4 per cent were born outside the State, and of the native negro, 59 per cent. Persons born outside the State constitute a larger proportion of the native population in urban than in rural communities.

Of the foreign-born white population of New York, persons born in Russia represent 20.5 per cent; Italy, 17.3; Germany, 16; Ireland, 13.5; Austria, 9; England, 5.4; Canada, 4.5; Hungary, 3.5; Sweden, 2; all other countries, 8.4. Of the total white stock of foreign origin, which includes persons born abroad and also natives having one or both parents born abroad, Germany contributed 21.5 per cent; Ireland, 19; Russia, 14.8; Italy, 12.9; Austria, 6.7; England, 6; Canada, 4.7; Hungary, 2.5; Scotland, 1.6; Sweden, 1.6 per cent.

Of the total population, 9.9 per cent are under 5 years of age, 17.4 per cent from 5 to 14 years, inclusive, 19.5 per cent from 15 to 24, 32.5 per cent from 25 to 44, and 20.6 per cent 45 years of age and over. The foreign-born white population comprises comparatively few children, only 7 per cent of this class being under 15 years of age, while 73.6 per cent are 25 years of age and over. Of the native whites of foreign or mixed parentage, 38.3 per cent are 25 and over, and of the native whites of native parentage, 49 per cent. The urban population shows a larger proportion of persons in the prime of life than the rural and a smaller proportion past middle age. Migration to the city and the influx of foreign immigrants explains this, at least in part. Of the urban population, 33.6 per cent are from 25 to 44 years of age, inclusive, and of the rural population, 28.3 per cent, while the percentages 45 years and over are 18.3 and 28.7, respectively. The large number of children in families of foreign origin may account for the fact that the proportion of children under 5 is greater in the urban population than in the rural.

The Census Bureau classifies as illiterate any person 10 years of age or over who is unable to write, regardless of ability to read. There are 406,020 illiterates in the State, representing 5.5 per cent of the total population 10 years of age and over, the percentage being the same as in 1900. The percentage of illiteracy is 13.7 among foreign-born whites, 5 among negroes, and 0.8 among native whites. For all classes combined, the percentage of illiterates is 5.9 in urban communities and 3.9 in rural, but for each class separately the rural percentage exceeds the urban. For persons from 10 to 20 years of age, inclusive, whose literacy depends largely upon present school facilities and school attendance, the percentage of illiteracy is 2.1.

In the population 15 years of age and over 39.8 per cent of the males are single and 33.7 per cent of the females. The percentage married is 55.2 for males and 54.5 for females, and the percentage widowed is 4.4 and 11.3, respectively.

* Reproduced from *Science*.

The Influence of Atmospheric Moisture Upon Automobile Motors

It is a matter of common knowledge among automobilists that in summer the motor works better, more smoothly and more regularly in the early morning hours and toward evening, when the air is moist. The cause of this effect is somewhat obscure.

According to *La Pratique Automobile* a French engineer, M. Patrouilleau, suggests a simple theory to account for the fact. He points out that in summer the air is not only moister at night than toward noon, but also cooler and therefore denser. While the carburetor may work less efficiently in moist than in dry air, the influence of the change in density more than compensates for this. This influence is quite markedly felt in ascending altitudes—there is a loss of 10 per cent in efficiency for every 3,000 feet or so. Furthermore, it must be borne in mind that the vapor pressure (vaporizing tendency) of gasoline rises very rapidly with the temperature, increasing forty-fold for the temperature range from the freezing to the boiling point of water. Hence the influence of temperature upon carburetion is very marked. On a summer's day the passage of a cloud over the sun is sufficient to produce a distinct effect, and the difference between the action of the motor in the morning and at night is due, according to M. Patrouilleau, to the same cause.

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